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PHYSICAL EDUCATION

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IN-DOOR LIFE.

"What is to the mind a healthy body,
To the body is a healthy house."
—Fabio Colonna.

Next to our dietetic sins, the abuses connected with our habits of domestic life have contributed the largest share to the great sum of human misery. Yet few evils might be more easily avoided. There are diseases which may be considered as visitations of national iniquities whose consequences are almost beyond the control of individuals; but for the sufferings caused by scrofula and pulmonary disorders we are indebted chiefly to our own prejudices. Prejudice and ignorance have filled more consumptives' graves than poverty. Even in large manufacturing towns air is free. If our artisans could realize the consequences of breathing miasma, they would prefer the life-air of the wildest wilderness to the lung-poison of their slums; like a caged bird, the tenement prisoner would refuse to pair rather than people the earth with cachectic wretches. The exodus of their workmen would soon induce manufacturers to imitate the founder of Saltaire; building speculators would find it to their advantage to adopt the Philadelphia plan, adding suburb to suburb rather than loft to loft; cities would grow outward instead of upward. A reform of that sort would imply various modifications of our present labor system; but before the enlightenment of public opinion such difficulties vanish like mist before the rising sun. There was a time when it was actually proposed to abolish the summer vacations of the French town schools "in order to enlarge their curriculum in proportion to the advance of modern

science"; but, since we have ascertained that out-door exercise is more important than all the graphies and ologies of the Académie Française, it has been found that, with a well-arranged plan of instruction ten months a year, five days a week and six hours a day are quite enough for any school. If the eight-hour system were generally adopted, operatives would not be compelled to live within ear-shot of the factory-whistle, and in very large cities the daily influx and reflux of a suburban multitude would enable railroad companies to carry individuals at rates which the poorest would call moderate. Far enough from the city center to evade the region of dear building-lots, and yet within easy reach of all kinds of door and sash factories and planing-mills, there would be no need of crowding three generations into a single room, and suffocating them with mingled kitchen-fumes and sick-bed odors. Three rooms and an out-house should be the minimum for a family with children.

In a tolerable location, the air of a three-room cottage can be kept pure enough without force ventilators or any other expensive contrivance. Open your windows; in very cold weather, air the bedrooms in daytime and the others at night. In larger houses, the kitchen, parlor, and dining-room should be thoroughly ventilated every night, also in daytime at convenient intervals, during the temporary absence of the occupants. To save foul air for the sake of its warmth is poor economy; experiments would show that the difference in fuel amounts only to a trifle, anyhow. Ten or twelve pounds of coal a day ought not to weigh against the direct gain in comfort and the prospective, unspeakable gain in health. Breathing the same air over and over again means to feed the organism on the excretions of our own lungs, on air surcharged with noxious gases and almost depleted of the life-sustaining principle. Azotized air affects the lungs as the substitution of excrements for nourishing food would affect our digestive organs: corruption sets in; pulmonary phthisis is, in fact, a process of putrefaction.

No ventilatory contrivance can compare with the simple plan of opening a window; in wet nights a "rain-shutter" (a blind with large, overlapping bars) will keep a room both airy and dry. In every bedroom, one of the upper windows should be kept open night and day, except in storms, accompanied with rain or with a degree of cold exceeding 10° Fahr. In warm summer nights open every window in the house and every door connecting the bedroom with the adjoining apartments. Create a thorough draught. Before we can hope to fight consumption with any chance of success, we have to get rid of the *night-air superstition*. Like the dread of cold water, raw fruit, etc., it is founded on that mistrust of our instincts which we owe to our anti-natural religion. It is probably the most prolific single cause of impaired health, even among the civilized nations of our enlightened age, though its absurdity rivals the grossest delusions of the witchcraft era. The subjection of holy reason to hearsays could hardly go further.

"Beware of the night-wind; be sure and close your windows after dark"! In other words, beware of God's free air; be sure and infect your lungs with the stagnant, azotized, and offensive atmosphere of your bedroom. In other words, beware of the rock spring; stick to sewerage. Is night-air injurious? Is there a single tenable pretext for such an idea? Since the day of creation that air has been breathed with impunity by millions of different animals—tender, delicate creatures, some of them—fawns, lambs, and young birds. The moist night-air of the tropical forests is breathed with impunity by our next relatives, the anthropoid apes—the same apes.that soon perish with consumption in the close though generally well-warmed atmosphere of our northern menageries. Thousands of soldiers, hunters, and lumbermen sleep every night in tents and open sheds without the least injurious consequences; men in the last stage of consumption have recovered by adopting a semi-savage mode of life, and camping out-doors in all but the stormiest nights. Is it the draught you fear, or the contrast of temperature? Blacksmiths and railroad-conductors seem to thrive under such influences. Draught? Have you never seen boys skating in the teeth of a snow-storm at the rate of fifteen miles an hour? "They counteract the effect of the cold air by vigorous exercise." Is there no other way of keeping warm? Does the north wind damage the fine lady sitting motionless in her sleigh, or the pilot and helmsman of a storm-tossed vessel? It can not be the *inclemency* of the open air, for, even in sweltering summer nights, the sweet south wind, blessed by all creatures that draw the breath of life, brings no relief to the victim of aërophobia. There is no doubt that families who have freed themselves from the curse of that superstition can live out and out healthier in the heart of a great city than its slaves on the airiest highland of the southern Apennines.

In such countries as Italy and Mexico, where the plurality of the population pass the daylight hours in open air, unventilated bedrooms are almost the only cause of tubercular diseases; but in the north, where children have to be nursed like exotic birds, the chief defects of our domestic arrangements may be classed under three heads: impure air, want of sunshine, and want of room for exercise. The *beau-idéal* of a healthy house would be a well-plastered stone building on some eminence, remote from swamps and stagnant creeks, but surrounded by sunny slopes available for play-grounds; spring or well water; out-door cellar, kitchen in an out-house, or at least not directly below the sitting and sleeping rooms; high ceilings, wainscots, or wall-paper of innocuous colors; deep windows, with projecting mullions to admit the air and exclude the rain; an airy veranda, and no shade-trees on the east and west side, as sunlight is most needed in the mornings and evenings. Children can not thrive in dark back rooms, and in the first eight years of their lives should have all the exercise they want. The countrymen of Dr. Fröbel are ahead in this respect, and the best-ar-

ranged nursery I ever saw was the *Findel-zimmer* ("foundling-ward") in the convent of the Ursuline nuns near Würzburg, Germany. The landed estate of the convent having been sequestrated, their department of charitable institutions had been reorganized on a more economical basis, and the poor nuns thought it necessary to apologize for the ingenious simplicity of their Zimmer, whose plan had been suggested chiefly by the necessity of dispensing with hired help. The room was about forty feet square, facing south and west, with three large windows on each side. These windows and the fireplace were barred with net screens, soft to the touch, but securely fastened, and strong enough to stop anything from a football to a forty-pound baby. The floor was carpeted with rugs, covered with a sort of coarse sheeting to prevent dust. From the floor to the height of the window-sills the walls were padded all round with old blankets, secured with muffled nails, and stuffed with something that felt like moss or cow's hair. The only piece of furniture was a cushioned divan in the corner next to the fireplace; but the floor was covered with playthings and movable nondescripts, balls of all sizes, and a big *Walze*, a sort of wooden cylinder, muffled up with quilts and cotton. From the center of the ceiling depended a hand-swing, two rings just low enough to be within reach of a youngster standing on tiptoe, the original sitting swing having been removed as liable to be used as a catapult in a general row. Above the windows, out of reach of the boldest climber, were shelves with flower-pots, reseda, gillyflowers, and wintergreen. In this in-door Kindergarten, fourteen playmates—twelve babies, namely, and two puppies—had been turned loose, and seemed to celebrate existence as a perpetual circus-game. They could run races, pelt each other with cotton balls, swing in a circle, roll on the floor, and ride the Walze; but the attempt to hurt themselves would have baffled their combined ingenuity. There were no nurslings, of course, but all mischief-ages from three to eleven, wrestling and quarreling now and then, but, as the nuns solemnly averred, never crying except for causes that would make the puppies cry—a squeeze or an inadvertent kick—all disputes being referred to the umpire, a flaxen-haired girl of eight, who often took charge of the Zimmer from morning till night.

The squalling of new-born children can not be helped; puppies will whine, and young monkeys whimper for the first three or four days—it is the novelty of existence that bewilders them—but, if babies of two or three years scream violently for hours together, it generally means that there is something wrong about the management. Indian babies never cry; they are neither swaddled nor cradled, but crawl around freely, and sleep in the dry grass or on the fur-covered floor of the wigwam. Continual rocking would make the toughest sailor seasick. Tight swaddling is downright torture; it would try the patience of a Stoic to keep all his limbs in a constrained position for such a length of time; a young ape subjected to the same treatment would

scream from morning till night. Forty per cent. of all children born in certain manufacturing districts of Belgium and Great Britain die before the end of the second year. They are swaddled, of course; they must not crawl around, and bother people; and "paregoric" does the rest: the child cries for liberty, and receives death. Opiates are sold under right pleasant names nowadays, and at popular prices in the larger cities; but a spoonful of arsenic would be a shorter and a kinder remedy.

Not every family has room and the means to construct a model nursery, but the poorest could spare a few square feet of space in some sunny corner, and, with old quilts and rugs, make it baby-proof enough for all probable emergencies. Then furnish a few playthings and trust the rest to nature. Man wants but little here below, and between meals a pickaninny will content itself with liberty, light and air, and a couple of rag-babies. As soon as a child begins to toddle, it should also have an opportunity to exercise its arms—a grapple-swing, or (if your ceiling be inviolate) a rope stretched from wall to wall. It is surprising how fast the clumsiest youngster begins to profit by such a chance. To the young son of man climbing comes natural enough to shock a witness of anti-Darwinian proclivities. The development of the shoulder-muscles also tends to invigorate the chest, and a fifty-cent hand-swing may save many dollars' worth of cough-medicine.

The progressive development of the motory organs prompts their frequent exercise, and there is no doubt that the gratification of this instinct constitutes the chief element of that physical beatitude which makes the age of childhood the spring-time of every life; and it is equally certain that compulsive physical inactivity inflicts on a healthy child an amount of wretchedness which no prospective advantages can possibly repay. It is hard enough that so large a portion of the human race have to rear their young in a latitude which half the year confines them to the freedom of their four walls; but it is harder that even this limited freedom should be curtailed by so many unnecessary restraints. I wish every houseful of children had a rough-and-tumble room, some out-of-the-way place where the cadets could romp, roll, and jump to their hearts' content. It need not be a heated room nor even an in-door place, as long as it has anything like a roof to it; children are naturally hardy, as they are naturally truthful: effeminacy and hypocrisy are twin daughters of our pious civilization. A wood-shed will do, or a lumber-room with old mattresses and hiding-places. Well-to-do parents might add some gymnastic apparatus, and for big boys a carpenter's table with an assortment of tools; mechanical dexterity may prove useful in many ways, and every normal boy has something of that instinct which phrenologists call *constructiveness*, and which makes the use of such implements a pleasure rather than a task. But, for the youngsters, the rough-and-tumble play is the main thing; it will strengthen their limbs, lungs, and livers, and

prevent more ailments than all the pills in Herrick's list of patent medicines. Moreover, it will keep them quiet where other children are sure to be fidgety—in the parlor and at school. Every school-teacher knows that young ruralists are more sedate than city boys; out-door work has given them all the exercise they need; they can take it easy while their comrades are fretting under an irksome restraint. After an hour or two of German gymnastics, combined wtth wood-chopping and water-carrying, if you like, the wildest boy will prefer a chair to a flying trapeze; for, if the tonic development of the organism is not grossly neglected, sedentary employments *per se* are by no means contrary to nature; in the intervals of their play, the young of frolicsome animals will sit motionless for hours; even kittens and young monkeys; not to mention colts which have off-days, when they won't stir a foot if they can help it.

It would be a great improvement on our present system of school-education, if children could learn the rudiments at home and pass their infancy, the first eight or ten years, at least, under the immediate supervision of their parents; a transition-period of three or four years of home studies would help them to steer clear of many moral and physiological cliffs. It is always the best preparatory school; only a private teacher has time and patience to *interest* a pupil in the dry *principia* of every science; but a still greater advantage is his independence of fixed methods and fixed hours. As a general rule, the forenoon is the best time for studies, and the airiest room in the house the best locality. Pure air has a wonderful effect on the clearness of our cerebral functions; the half-suffocating atmosphere of the average schoolroom is as stupefying as the influence of a half-intoxicating drink. Heat aggravates the offensiveness of foul air; but in a well-ventilated room the degree of temperature is comparatively unimportant. As it would be inconvenient to load ourselves with blankets in daytime, less than 50° Fahr. would make sedentary occupations rather uncomfortable, and more than 80° would become oppressive in a close apartment; but between these extremes we may safely suit our convenience. Perfectly pure or perfumed air may be very warm and still very pleasant, as all know who have entered a conservatory or a tidy baker's shop on a cold winter day.

In large town schools, where hundreds of children have to breathe the same air, I would advise a change of rooms from hour to hour, and a thorough renovation of the vitiated atmosphere by opening every window and every door, and keeping up a rousing fire. The air-currents could be reënforced by mechanical means—canvas-floppers or revolving fans—and *fumigation* would greatly aid the good work. The South European druggists sell various kinds of frankincense that can be burned on a pan or a common stove, and will fill a large church with odors more or less Sabæan, according to price—ten cents' worth a day would be enough to beatify a whole town school; Mohammed, the

man of God, included perfume among the three greatest blessings of human life. Young children ought to have a recess after every lesson, and should not be required to sit rigidly quiet. The best writing-stand for children is Schreber's "telescope-desk," a box-like contrivance, with a movable top that can be lowered or raised to suit the convenience of sitting or standing writers. In a latitude where the weather so often precludes the possibility of out-door recreations, every schoolhouse should have a recess-room, and every town school an in-door gymnasium.

Fireside comforts are almost inseparable from the idea of an open fireplace, and from an hygienic standpoint, too, the old-fashioned chimney, or an open grate, is far superior to a closed stove. But it should not be forgotten that the operation of the chimney-draught alone is insufficient to correct the vitiated air of a small room, it merely creates an outward current. An open window completes the renovating process; in cold weather a few minutes are sufficient to revitalize the indoor atmosphere for a couple of hours. Only the blindest prejudice can deny the pleasant effect of such an influx of life-air; it revives the azotized lungs as a draught of cool water refreshes the parched palate. Colds are never taken in *that* way. The very name is a misleading misnomer—*infection* or influenza would be the right word. Long exposure to a freezing storm, in certain cases, induces a true pleuritic fever, a very rare affection, and entirely different from the only too familiar catarrh. What we call a *cold* (*refroidissement*, *Erkältung*) is caused by the influence of impure air, or dust, on the sensitive tissue of our respiratory organs; subsequent exposure to the open air merely initiates the crisis of the disorder, the discharge of the accumulated mucus through the nose or throat. Fresh air is here only the proximate cause, as in toothache, or in those paroxysms of retching following upon the first respiration of a half-drowned person. If we postpone the crisis by persistently avoiding the open air, the unrespirable matter, instead of being discharged, will be deposited in the tissue of the lungs in the form of tubercles.

In the chapter on Diet I have stated the physiological objections to a late supper, and I will here mention an additional reason why the afternoon meal should be the last: It would give an overworked mother a chance to close the kitchen-door at six o'clock, and devote the rest of the evening to her family. Domestic habits depend greatly upon the employment of the long winter evenings that have to be passed indoors somewhere; whether at home or—elsewhere, depends upon home-comforts rather than upon home-missions; a treatise on the art of making the chimney-corner attractive would be the most effective temperance lecture. Fredrika Bremer recommends fairy stories; in a North American city Scheherezade would probably avail herself of the circulating library, and a fascinating story-book is, indeed, an excellent substitute for the old-fashioned remedies against gadding. Good

books, flowers, and music, combined with pleasant conversation and a cheerful fire, would neutralize the attractions of the average "saloon." Playthings and social games, too, would help to compensate the youngsters for the want of out-of-door sports, and where they have a room to themselves I would suggest the introduction of some entertaining pet, a raccoon or a tame squirrel-monkey. Let the boys have some fun—provide pastimes; it is *ennui* rather than natural perversity that leads our young men to the rum-shop.

The end of the day is the best time for a sponge-bath; a sponge and a coarse towel have often cured insomnia where diacodium failed. A bucketful of tepid water will do for ordinary purposes; daily cold shower-baths in winter-time are as preposterous as hot drinks in the dog-days. Russian baths and ice-water cures owe their repute to the same popular delusion that ascribes miraculous virtues to nauseating drugs—the mistrust of our natural instincts, culminating in the idea that all natural things must be injurious to man, and that the efficacy of a remedy depends on the degree of its repulsiveness. Ninety-nine boys in a hundred would rather take the bitterest medicine than a cold bath in mid-winter. If we leave children and animals to the guidance of their instincts they will become amphibious in the dog-days, and quench their thirst at the coldest spring without fear of injurious consequences; but in winter-time even wild beasts avoid immersion with an instinctive dread. A Canadian bear will make a wide circuit, or pick his way over the floes rather than swim a lake in cold weather. Baptist missionaries do not report many revivals before June. Warm springs, on the other hand, attract all the birds and beasts that stay with us in winter-time; the hot spas of Rockport, Arkansas, are visited nightly by raccoons and foxes in spite of all torchlight hunts; and Haxthausen tells us that in hard winters the thermæ of Paetigorsk, in the eastern Caucasus, attract deer and wild-hogs from the distant Terek Valley. I know the claims of the hydropathic school, and the arguments *pro* and *con*, but the main points of the controversy still hinge upon the issue between Nature's testimony and Dr. Priessnitz's.

Our beds are our night-clothes, and ought to be kept as clean as our shirts and coats. Woolen blankets are healthier than quilts; put a heavy United States army blanket over a kettle full of hot water and see how fast the steam makes its way through the weft; a quilt would stop it like an iron lid, and thus tends to check the exhalation of the human body. In order to disinfect a quilt you have first to loosen the pressed cotton; a woolen blanket can be steamed and dried in a couple of hours. For similar reasons a straw tick is better than a horsehair mattress, though a woven-wire mattress is perhaps preferable to both. Feather-beds are a recognized nuisance. Children over ten years should sleep alone, or at least under separate blankets, if the bedsteads do not reach around.

If you would preserve your children from wasting diseases, do not stint them in their sleep; chlorotic girls, especially, and weakly babies need all the rest they can get. If they are drowsy in the morning, let them sleep; it will do them more good than stimulants and tonic sirups. For school-children in their teens, eight hours of quiet sleep is generally enough, but do not restrict them to fixed hours; in mid-summer there should be a *siesta*-corner in every house, a lounge or an old mattress in the coolest nook of the hall, or a hammock in the shade of the porch, where the little ones can pass the sleep-inviting afternoons. Nor is it necessary to send them to bed at the very time when all nature awakens from the torpid influence of the day-star; sleep in the atmosphere of a stifling bedroom would bring no rest and no pleasant dreams. But an hour after sunset there will be a change; the night-wind rises and the fainting land revives; cool air is a febrifuge and Nature's remedy for the dyspeptic influences of a sultry day. Open every window, and let your children share the luxury of the last evening hour; after breathing the fresh night-air for a while, they will sleep in peace.

THE PROBLEM OF MUNICIPAL NUISANCES.

By ROGER S. TRACY, M. D.

THE general democratic tendency of the past three hundred years has had some curious results. Free thought and free speech have brought about a universal freedom in criticism, so that, at the present time, singularly enough, it has come to be looked upon as a sign of high civilization and progress for every man to have an opinion about everything, whether he knows anything about it or not. One of the most complicated political problems that men have ever had to treat, viz., the Eastern question, is discussed in this city, by individuals and newspapers, with more readiness and assurance than in the council-chambers of Berlin or London, and every man above the condition of a rag-picker will give you his opinion on the philosophy of evolution. This exaggerated sense of self-importance brings with it not only the tendency to criticise everything not in accordance with each person's notion of what is right or expedient, but, inasmuch as conflicting currents of thought and action are unavoidable, a profound feeling of dissatisfaction with one's own environment. This feeling of dissatisfaction shows itself in curious ways. In place of the intense patriotism and personal loyalty of past ages, we find a widespread belief in almost all highly civilized nations that things are better managed elsewhere than at home, and the newspapers, here and abroad, are crowded with this not-always-well-based self-criticism. New York newspapers are

great sinners in this respect. While they are continually extolling the natural advantages of the city, her magnificent river-front and harbor, her advantageous situation, her brilliant sky, they are also constantly bewailing her bad government, her lukewarm public spirit, and the universally asinine quality of her public officers. One would think that her present position as a metropolis is entirely due to natural advantages, and has been gained in spite of the most earnest opposition from her leading citizens. The elevation of an honest, sober, intelligent citizen to a public office makes him straightway an ass in the estimation of his fellows. A public officer, who declines to do what certain citizens want him to do, is believed by them to be *prima facie* corrupt. If he agrees to do what they wish, some other citizens are equally certain that he has been bought. It seems impossible for a man to remain in public office in New York City for six months without having charges or intimations of bribery come to his ears, in one form or another. And not only are our public officers all supposed to be open to corrupt influences, but, when they are put in office, they are believed *ipso facto* to become suddenly ignorant of all that they knew before. And not only are they taunted with ignorance, incapacity, and an itching palm, but they are continually reminded that things are much better managed elsewhere, and that the sooner they learn how a city ought to be governed, by observing how other cities are governed, the sooner they will become of some use in their places.

One of the things New-Yorkers complain most about is the dirty streets, including the garbage-box nuisance. It is a popular belief, fostered by the leading newspapers, that New York is the only large city in the civilized world where such a filthy nuisance as the garbage-box would be tolerated, and those officers who have charge of the public health are continually reminded of Paris and London, where no such frightful eyesores exist, and where the public service in this regard is immaculate, as every person who has taken a flying summer trip through those cities is ready to testify.

Another frequent cause of complaint is the offensive odors from manufacturing establishments, which also are believed to be kept under such strict watch in Paris and London that they are never nuisances; and the American visitor, being sure that such things are banished from those cities, wants to have them driven out of this one.

The purpose of this paper is not to show that the complaints of our citizens are unfounded, for they are, unfortunately, too well founded, but to do something toward stemming the prevailing current of opinion —1. That the dirty streets and offensive odors of New York are entirely due to the negligence, stupidity, or corruption of public officers; and, 2. That Paris and London are free from the same kind of nuisances. I shall, in other words, try to show that Paris and London, in similar circumstances, are troubled with dirty streets and offensive odors, depending upon the same causes as in New York, and that the public

officers of those cities find precisely the same difficulties in abating such nuisances that are met with here; and I submit that the public officers of the city of New York ought not to be called or considered stupid, ignorant, or corrupt, because they meet with the same difficulties as the intelligent, honest, and trained public officers of Paris and London, and, like them, do not always succeed in surmounting them to the satisfaction of the public.

This is not the place for a complete discussion of the subject of street-cleaning, but it may be well, as a preliminary to what follows, to call attention to some points on which there is decided popular misapprehension. It is believed by most citizens of New York that ample funds are given to the Bureau of Street-Cleaning, and that, if this money were honestly expended, our streets ought to be as clean as those of Paris. Now, the facts of the case are these:

Our Bureau of Street-Cleaning employs 387 street-sweepers. Paris has a permanent corps of 3,180, besides 190 machines, each doing the work of ten men. Our bureau has to clean, more or less perfectly, 1,415 acres of paved street surface; Paris, 2,667 acres. The great difference in force, in proportion to the work to be done, is apparent at a glance. Our sweepers are paid $1.60 per day for eight hours' work. The Paris sweepers receive sixty cents per day for ten hours' work. For the sake of ease in calculation, we will suppose that as much work is done here in eight hours as in Paris in ten hours. Then each sweeper in New York costs a dollar a day more than each one in Paris. From the figures already given, the following results may be deduced:

If New York sweepers received Paris wages, we should, with our present force, save yearly $141,255.

If New York sweepers received Paris wages, we could, without increasing the expense of street-cleaning, increase the force by 645 men, i. e., nearly treble it.

If there were as many sweepers in New York as in Paris, in proportion to the area required to be cleaned, the expense of street-cleaning in New York would be increased by $474,500.

If Paris sweepers received New York wages, the expense of street-cleaning in Paris would be increased by $1,160,700.

As a matter of fact, the expense of street-cleaning in New York for 1879 was $690,000, including $40,000 for removing ice and snow; and in Paris for 1878, $817,000, including $181,000 for the removal of ice and snow.

An important part of the duties of a street-cleaning bureau is the removal of ashes and garbage. It is also exceedingly difficult, in a large city, to do this effectively and economically. I say, in a large city, for in a small village the garbage nuisance is at its minimum, and it increases with the number and crowding of inhabitants. It is unfair to compare the New York method of removing ashes and garbage with that of smaller and less compact towns, like Boston and

Philadelphia. The difficulties to be surmounted in this city are even greater than in Paris or London, because of the peculiar shape of the city, and because we are surrounded by water. But this is a digression.

It is a common belief, reiterated in the daily journals, that the household and street refuse of Paris is sold for enormous amounts, and that so much money is received on this account that the street-cleaning service of that city is a source of revenue instead of expense. This is not so. The chief revenue in this regard is derived from the rag-pickers. In New York these people ransack the boxes and barrels on the street, without paying for the privilege, and all that they collect brings them a clear profit. In Paris, on the other hand, the privilege of rummaging the dust-heaps is farmed out to wealthy contractors, who employ about 7,000 *chiffoniers*, and have a monopoly of rag-picking. So far as I can ascertain, this is the only source of actual revenue to the city of Paris from its street refuse, and what the amount of this revenue is I can not learn. It is very hard to find out anything about the municipal expenditures of that city, as it has no official journal like our "City Record."

Now, let us see what are the practical results of the methods of street-cleaning and removal of household refuse adopted in Paris:

"Street-cleaning in cities has for its aim the removal of dust, mud, snow, filth, and household refuse. As regards the latter, which ought to be thrown directly into the carts, municipal regulations in Paris continually conflict with a corporation very jealous of its privileges; I refer to that of the rag-pickers, who conduct a business represented by nearly 7,000 persons, collecting with their hooks material worth 4,000,000 francs ($800,000) a year, and feeding the manufactories of paper, pasteboard, lampblack, etc. We are obliged, therefore, to yield to the demands of these Diogenes of the street, and to allow, to the great prejudice of sight, smell, and health, the throwing upon the public street, toward evening, of all kinds of refuse, to be picked over by the hook of the rag-picker. They insist upon this, and they wield a great power."—(Fonssagrives, "Hygiène et Assainissement des Villes," Paris, 1874, p. 174.)

"In Freycinet's opinion ('Assainissement des Villes,' p. 343), as far as promptness and completeness of street-cleaning in the narrower sense are concerned, Paris is in advance of all other great cities; but it is not so with the household refuse, which, in the absence of special means of removal, must naturally take its way over the street. Although this refuse, intended for removal and thrown on the street for this purpose, *ought to be taken away at an early hour of the morning, it often remains upon the street till evening, is scattered about, etc.*, and all, according to Freycinet, because they do not wish to interfere with the unhealthy occupation of the rag-pickers, who rummage the mess for rags and bones."—(Götel, "Oeffentl. Gesundheitspfl. in den Ausserdeutschen Staaten," Leipsic, 1878, p. 205. The italics are mine.)

Götel states that things are much better managed in Lyons and Bordeaux in this respect—very much smaller cities, be it noted.

So it appears that the problem of the expeditious and inoffensive removal of household refuse has not yet been solved in Paris, the opinion of amateur sanitarians in this country to the contrary notwithstanding.

Last December there were two heavy snow-falls in Paris, only four days apart. The first storm crippled the street-cleaning department, and after the second the authorities were almost in despair, being hampered, as ours are, by the lack of funds, and, while their hands were tied, being harassed, howled at, and snapped at by the journalistic jackals. Almost a complete history of this episode can be gathered from the following comments of the press:

"As regards locomotion, the streets are gradually becoming more practicable for both riding and walking, thanks to the army of sweepers that the municipal authorities have at length set to work. It is remarked, however, that on the occasion of the last heavy fall of snow in Paris, some five or six years ago, the public thoroughfares were cleared much more rapidly than this time, owing to the military having been engaged in the task, and some surprise is expressed that they were not made use of this year. Certain it is that the public have had to suffer much loss and inconvenience, which they might have been spared by more prompt and energetic measures on the part of the authorities."—(London "Standard" Paris correspondent, December 8, 1879.)

"In some of the public gardens the snow is untouched, and they have ceased to be thoroughfares; but in the streets it is slowly being carted away, the traffic being carried on under great difficulties. Most of the tramways have stopped working."—(London "Times" Paris correspondent, December 10, 1879.)

The depth of snow that fell in these storms was estimated to be fifty centimetres (twenty inches). The chief of the Department of Public Works, M. Alphand, being called upon to explain why he did not immediately remove it all, stated that there had fallen altogether about 7,000,000 cubic metres of snow, and that it cost three francs a cubic metre to remove it, or 21,000,000 francs for the whole (about $4,000,000). The Municipal Council did not feel authorized to expend this vast sum, but they did generously vote 500,000 francs ($100,000), in addition to the regular appropriation for street-cleaning, and M. Alphand was thus enabled to put an immense force at work upon the streets.

It is worthy of notice how differently this public officer was treated from our own. In the spring of 1879 our Police Commissioners were summoned before the Mayor, and two of them removed from office because they had not kept the streets clean during the winter. No extra appropriation for them—nothing but disgrace! A comparison of the condition of the streets in both cities may be instructive. In

Paris twenty inches of snow fell in December, eight inches at one time and twelve at another. And this was a remarkable event in that city, although such storms are not uncommon here. For instance: on February 3, 1876, we had eleven inches of snow; on January 13, 1877, thirteen inches; and March 16th following, three and a half inches. In the winter which proved so unfortunate for our public officers, we had, on January 1, 1879, five inches of snow, and on the 16th thirteen inches more, or eighteen inches in all, and nearly as much as fell in Paris last winter. Between these storms we had freezing weather, the thermometer marking above the freezing-point only six times, and never rising above 38° in the hottest part of the day. So the cases are not altogether dissimilar. Let us see how much better the efficient street-cleaning department of Paris did its work than ours.

The following extracts are from the "Figaro" of December 10, 1879:

"'La Presse' says, 'A little less politics, and a little more sweeping.'

"'Le Mot d'Ordre': 'A little more sweeping! "La Presse" is right; let them sweep out the head of the bureau.'

"'La Presse': 'We have lived in countries where snow is not an exception, as it is in Paris. In those places snow has never been an obstacle in getting about the streets. As soon as the snow begins to fall, they sweep it up and carry it away.'"

And "Figaro" adds: "All this is perfectly true; in London, they melt the snow instantly with jets of steam; in Berlin, where it snows almost constantly in winter, the street-cars do not cease running for an instant, owing to analogous measures, which keep the rails absolutely free. But we are in France, we are in Paris; and a practical spirit is, unfortunately, the only thing we lack."

How much all this sounds like the talk of our own newspapers!

The attacks of the press were so persistent, and the displeasure of the public so marked in various ways, that M. Alphand was summoned before the Municipal Council. In his speech, reported at length in "Le Figaro" of December 12, 1879, he referred in the following words to some of the statements made in the newspapers:

"Foreign countries have been mentioned; it has been stated that in them the snow is removed immediately. Brussels has been given as an example; now I myself was in that city three years ago, at the very time when they had a fall of snow; I declare to you that I did not see a single cart carrying away snow, and when it thawed people splashed along in a black mud twenty-five centimetres thick" (ten inches).

M. Alphand stated that there were at that time employed in removing snow 13,940 men, 3,900 horses, and 2,400 carts.

Imagine our Board of Apportionment supporting the hands of its public officers, in trying times, in this fashion!

This immense body of laborers was put at work before the middle of December. And how much did they accomplish?

On January 5th a correspondent writes: "Beneath our feet such mire as has not been seen since the first week succeeding the original deluge. . . . *From the first fall of snow, upon the 4th of December, the regular scavenger service was suspended, and now, that the snow has melted away, great heaps of offal and filth of all sorts lie rotting in the open air.*" (The italics are mine.)

In a letter to the "New York Evening Post," dated at Paris, January 6th, Edward King writes: "Coming into the city after a brief journey to Spain a day or two since, I almost fancied myself in New York, so familiar seemed the long banks of snow, garnished with dirt and the refuse from kitchens. The municipal authorities have been unable to maintain their reputation for promptness in street-cleaning, in presence of the unaccustomed snowy visitation."

As late as February 18, 1880, more than two months after the snow-fall, and with mild weather intervening, notwithstanding the efforts of 14,000 men and the expenditure of $100,000, "Le Figaro" has the following paragraphs:

"There still remain, in many of the side streets, disagreeable reminders of the snow of last December. Thus, to mention only one instance, but one that counts, we call attention to the streets and passages of the districts bordering on the Eighteenth Ward (arrondissement). The streets and narrow alleys lying between the Rue Ordener and the fortifications, and between the long Rue des Poissonniers and the Avenue de Saint Ouen, are in a wretched state. Heaps of filth, composed of earth-mixed snow, vegetable scraps, and refuse of all kinds, stagnate in the puddles formed by the holes in the pavement.

"The complete repair of this pavement is absolutely necessary. The old women of the quarter quarrel every day about who shall clean in front of the houses, and the streets remain filthy.

"Between the passages Traëger and des Poissonniers there is an open space of about one thousand square feet" (one hundred square metres). "This space is now a mere slough of filth, where the inhabitants, careless of sanitary laws, deposit the most unseemly products of their meals." (Something left to the imagination here.)

"Let there be a hot sun, and an epidemic will sweep away the tenants of these hovels by the hundred.

"Note to the Commission of Hygiene and Public Health, and to the ashmen. The tenants of this quarter have lost the habit of seeing these men."

The extraordinary parallelism between such passages and the comments of our own newspapers in the spring of 1879 will be noticed by every one.

Query? If 14,000 men and $100,000 are unable to clean 2,667 acres of street in Paris in two months after a snow-fall of twenty inches,

what ought in justice to be expected from a force of 400 men, with no extra appropriation, working on 1,415 acres of street in New York, after a snow-fall of eighteen inches?

In London, such snow-storms never occur; but, that the authorities find it difficult there also to keep the streets in that condition of perennial neatness demanded by the press and the public, the following extracts will show:

"There is a natural dowdiness about the streets of London, especially in autumn, which is perhaps incurable. . . . The pavements begin to be deeply smeared with that peculiarly nasty London slime, which can only here be produced in its glutinous and slippery perfection."—("Saturday Review," November 1, 1879, p. 531.)

"The streets of London are being much improved by wood pavement" (they will find this a mistake), "but they are still allowed to remain in a condition of dirt which can not be otherwise than very injurious to the public health. London smells are as objectionable as London noises, and in removing the latter some attempts might with advantage be made at least to diminish the former. This end would in great measure be attained by a proper system of street-cleaning. Under existing arrangements there is no provision for a thorough and periodical cleaning of the roads. They are not even swept, the result being that in dry weather they are littered with refuse and abominations of various sorts, which pollute the atmosphere and fully account for the *unpleasant odors which have during the present summer prevailed in the metropolis and been the cause of general complaint.* Water-carts are of very little service in washing the streets; they may lay the dust for the time, but they merely transform it into mud without removing it. Heavy thunder-showers exercise a more beneficial effect, but their visitations are uncertain, and the manure they wash into the drains often stagnates in the sewer, and might be turned to profitable account if collected and disposed of. The attention of the vestries has lately been called to the whole question of street-cleaning by the National Health Society, and the sooner some steps are taken to purify out-door as well as in-door London the better."—("St. James's Gazette," quoted in "New York Sun," September 5, 1880. The italics are mine).

The bad odors above mentioned are also referred to in the following extract from the "Lancet" of May 29, 1880: "Attention has at length been drawn in the daily press to the disgusting smells pervading many of the principal London streets at the present moment. A correspondent likens the smell in Victoria Street, Westminster, to that of a charnel-house; and the smell in the Quadrant, Regent Street, on Friday and Saturday last, was so like that of carrion, that we heard the question debated whether it did not come from some open windows in the houses near the spot where it was felt" (*sic!*), "and might not arise from some, perhaps unknown, carrion there. But this is not the

only part of Regent Street which has recently been distinguished by a foul smell. The stench (arising from foul sewage according to some, from foulness of the roadway according to others) has been specially obvious to the passer-by about the center of the street, and between Oxford Circus and Margaret Street. In the latter place it was particularly disgusting on Saturday evening. Other streets in the West of London have, and are, suffering from persisting stink" (*sic!* punctuation and all). "It has been suggested that this offensive state of things has arisen from the long spell of dry weather, and consequent insufficient flushing of the sewers or streets, or both. But are the sanitary authorities of the metropolis so wanting in ingenuity, energy, and means that the effects of absence of rain upon the sewers and streets at this time of the year can not be counteracted?"

From the above it appears that New York is not the only city where rain is expected to help in cleaning the streets, or where the public authorities are expected to make up for the meteorological defects of an exceptional season.

In the removal of ashes and garbage, London does not seem to be much in advance of New York, as witness the following extracts: "What can be more unreasonable than the practice of accumulating kitchen stuff and household dirt of every description in heaps under our windows during the heat of summer? . . . The scavenging of our cities and towns is done by contract, and the men employed in the work are so underpaid that, as a matter of experience, they decline to discharge their duty except when bribed by householders. Complaints reach us of the extent to which the practice of levying black-mail is carried by the London dustman, and doubtless the evil is rife elsewhere. Servants are powerless to compel the inert and insolent men who parade the streets with carts to empty the dust-bins. . . . Altogether, the system of clearance is a *fiasco.*"—(London "Lancet," August 17, 1878, p. 233.)

Substitute garbage-box for dust-bin in the following letter,* and it might do for the complaint-book of the "Herald":

MEADOWSIDE, PUTNEY, *September* 20, 1880.

SIR: At an inquest held a few days ago on the body of a child who died at Lisson Street, Marylebone, the coroner, Dr. Hardwicke, commented strongly on the serious injury to health occasioned by the present system of allowing dust-bins to remain in London and its environs for lengthened periods without being cleaned out. Perhaps you would bring your influence to bear in this matter, which certainly appears to me to require looking into.

An uncleaned dust-bin, with its festering mass of decaying animal and vegetable refuse, particularly in hot weather and in crowded districts, is a grave evil, as any one who has given the slightest attention to the matter of hygiene will allow, and the present system of having them emptied once in a fortnight is simply absurd. Of course, *those who are addicted to cleanly habits can have their*

* London "Lancet," October 2, 1880, p. 563.

dust-receptacles attended to oftener by entering into a private contract with the dustmen; but those whose means are straitened, or who can not afford this luxury, must be content to endure their pestilence-breeding bins, with all the foul odors and health-depressing influences attached to them, until such times as it may please the dustmen to give them a *dirty clean-out*, the visits of these gentlemen being, like those of the angels, "few and far between," in the poor and crowded districts of this great city.

I have frequently been told by members of the working classes that *it is no unusual thing for the dust-bins in their neighborhood to remain unattended to for months at a time;* and, when they appeal to the dustmen in charge of any passing cart, they are either laughed at or met by a volley of abuse for their pains.

Surely such a state of things, which is easy of remedy, should not any longer be permitted. Yours truly,

G. STANLEY MURRAY, M. D.

The italics in this letter are mine. The writer shows his imperfect acquaintance with the necessities and difficulties of the public service, in the last paragraph, when he writes, "which is easy of remedy." To be sure, the remedy seems plain enough to any one who has never tried to make his own plan work practically. All that is needed is a few carts, horses, and men, with system, energy, intelligence, and industry—men with the latter qualities, as is well known, being exceedingly plentiful in the world, and their services dirt-cheap. A writer in the "Contemporary Review" for October, 1879, page 294, Henry J. Miller by name, representing himself as a poor man appealing to the upper classes for aid in bettering the condition of the poor, makes the following suggestion in his article "Lazarus to Dives," which, as an off-hand solution of a great problem, equals anything in our own daily journals: "Furnish" every householder "with two boxes, varying in size according to the dimensions of his domicile: one to form a receptacle for dust, cinders, old rags, broken bottles, and what is generically known as 'dry dirt'; and the other for decayed vegetables, the entrails of fish, and that kind of refuse that we rather uneuphoniously call 'muck.' Such boxes to be taken away once a week, and empty ones left in their stead. As a corollary to this, forbid him, under penalties, to continue his present practice of pitching derelicts into the street, as the readiest means of being quit of them; and make him responsible for the cleanliness of his door-steps and the pavement in front of his dwelling."

I have but one more subject to touch upon. In the spring of 1878 a determined effort was made by a public-spirited citizen to have the Health Commissioners of this city punished because they did not drive all offensive businesses out of the city. The attack upon them failed, and it failed for the same reason that similar attacks have failed, and will fail elsewhere, and that is, because the trades classed as offensive constitute an important part of the industries of a great city, and their banishment would strike a terrible blow at her commercial prosperity.

The meat business alone in New York runs up toward a hundred millions annually, and the city can not afford to lose it, with the hundreds of smaller allied businesses that must inevitably follow it wherever it goes. I have brought up this subject because, singularly enough, the same trouble and similar complaints have arisen in Paris this summer, and the parallelism between the course of the journals there and here is as marked in this case as in the others mentioned above.

The Paris correspondent of the London "Lancet," in the issue of July 31, 1880, writes: "For some time the atmosphere of Paris has been anything but agreeable. Toward the evening, an unpleasant smell—or rather a more unpleasant smell than usual—has been noticeable, so much so, indeed, that it has at last become offensive even to the republican nostrils of the Municipal Council. This odor has been supposed by some to emanate from the sewers, while others have attributed it to putrefaction in the numerous *kiosques* which adorn (or disfigure?) the boulevards. It would appear, however, that the effluvium originates outside the fortifications, in the twenty-seven *dépotoirs*, or night-soil depots, which at some distance surround the capital, and perhaps also in the sewage-boats which are anchored in the Seine, near the Pont des Invalides. It depends in a great measure upon the absence of the disinfectants which should be used by the contractors who empty the cesspools, but who appear, from the statement of one of the Municipal Councilors, to have been abetted by the police in their neglect."

A month later, August 28th, the same correspondent writes: "The pestilential smells which have infected Paris for some time are awakening a feeling of indignation against the responsible authorities, which is expressed freely in the daily papers, and that quite independent of party spirit. A few days since the well-known critic, Francisque Sarcey, devoted an article to this matter in the 'Dix-Neuvième Siècle,' and invited the inhabitants of his district to sign the petition in preparation against the nuisance; and the 'Figaro' of to-day prefaces some satirical remarks by the statement that 'Paris est en ce moment infecté par les odeurs les plus épouvantables. Tous les égouts sont à découvert.' The odors, which in reality emanate, as was stated in a previous letter, from the night-soil *dépotoirs* which surround the city, and also from the carts and boats which convey the sewage outside the walls, are due to the neglect of the contractors in the use of disinfecting measures, and *there seems to be no doubt about the connivance of the police at this abuse.* . . . The 'Petite République Française' thinks that *the only remedy lies in the suppression of the bureaux which are fallaciously called 'sanitary' or 'hygienic,'* and which cover the responsibility of the prefect by a semblance of official sanction, which, as a matter of fact, they can not withhold." (The italics are mine.)

The usual hasty charges of corruption and incompetence, it will be observed, and the usual expression of a belief that matters could be mended by turning the incumbent officers out of their places and putting green men in their stead!

Meanwhile the Council of Hygiene was busily at work tracing the source of these odors, and endeavoring to find means of suppressing them. The "Journal Officiel" of October 7, 1880, contains the report of a commission appointed for this duty, in which they take strong ground with regard to the harmlessness of the odors, so far as the public health is concerned. It has always been maintained by the Board of Health of this city that the odors complained of by our citizens were not detrimental to health, but only destructive of comfort, and its officers have been much ridiculed for this opinion. It is not unpleasant, therefore, to find that the corresponding board in Paris takes the same view. The following extract will show this:

"The commission deems it necessary, in the first place, to reassure the public with regard to the influence exercised by sewer emanations upon mortality and upon the diffusion of contagious or epidemic diseases. In a communication to the Academy of Medicine, March 6, 1877, M. Bouley has stated that the proof of this contagious action, far from being demonstrated, was contradicted by certain observations. This doctrine has been maintained in the Council of Hygiene, by MM. Bouchardat and Hillairet, whose authority in such matters is well known. The emanations from the mouths of sewers, as well as those from the great chimneys of our factories, do not contribute, in any degree whatever, to the development or propagation of epidemic affections."

In this report, the bad odors complained of in Paris, especially during August and September, penetrating to the center of the city, are attributed to the ventilating shafts of "fosses d'aisance," the dépôts des vidanges at Billancourt, Aubervilliers, and Les Hautes-Bornes, Arcueil. As remedies they recommend the prompt prosecution of persons who discharge night-soil into the sewers (which is not allowed in Paris, and accounts for the cleanliness of her sewers), the thorough flushing of the sewers, a vast increase in the water-supply for cesspools and water-closets, the ventilation of the sewers, and the strict supervision of fat-rendering establishments. And they add that, "in seeking these means of prevention, we do not lose sight of the just recommendation of the Minister of Agriculture and Commerce, dated January 7, 1878, that *they ought to be practicable and susceptible of being put in operation without entailing the suppression of the manufactures themselves.*" (Italics in original.)

The report lays great stress upon the facts that the odors from poudrette-works, fat-rendering establishments, fertilizer-works, etc., are not injurious to health, and that a suppression of these works, such as the public demands, would result in great inconvenience and even

danger to the city : "Il faut le reconnaître, ce sont des établissements nécessaires."

M. Alphand, chief of the Department of Public Works, who was held partly responsible by the public for the state of affairs, made a speech before the Council of Hygiene, October 1st, which is reported in the "Journal Officiel" of October 7, 1880. He speaks more at length than the commission above-mentioned with regard to establishments of the kind that have caused so many complaints in New York. He says :

"The abattoirs of La Villette give rise, as our colleague Dr. Voisin has remarked, to disagreeable odors. These odors do not come, as has been supposed, from the barge which receives the manure and entrails of the slaughtered animals ; those matters are, in fact, thoroughly disinfected and removed daily. The bad smells which escape in the vicinity of these abattoirs of La Villette are produced by the fat-rendering, which is done immediately after the killing. This is a nuisance inevitably connected with all establishments of this kind. . . .

"There is, at the gates of Paris, between the Chemin de Fer du Nord and the canal, all along the street La Haie-Coq to Aubervilliers, a collection of factories that treat animal matters and spread abroad nauseous smells. . . . It can not be too strongly insisted upon that these emanations, so objectionable to the sense of smell, have no miasmatic character, and are not dangerous in a medical point of view. . . .

"An evident proof of the harmlessness of these odors, as far as the public health is concerned, is found in the following figures : The complaints of bad odors began in August and increased in intensity up to the month of September. Now, the mortality lists, for the first week of August, show 1,114 deaths ; the list for the week from September 9th to 16th shows only 881, a number smaller than the average when Paris is in the best sanitary condition."

The following words of M. Alphand are worthy of consideration here in New York :

"Besides, the public must not demand the impossible, and the production of emanations more or less disagreeable, more or less offensive, can never be completely avoided in the midst of this collection of two million human beings, and many hundreds of thousands of animals—dogs, cats, horses, cattle, poultry, etc."

The speech of M. Alphand was not dealt with tenderly by the newspaper men, who naturally knew much more about the subject than he did. M. Francisque Sarcey, in the "XIXième Siècle," scarifies him in the following terms, which lose much of their vigor and sarcastic force in the translation :

"M. Alphand deduces from this very unanimity an argument against the press ; it is the newspapers, he says, that have thrown bitterness into the question. It is they who have made all the trouble !

By crying out against the bad smells, they have finally persuaded the Parisians, and even foreigners, that these bad smells really exist. Before this concerted outcry, Parisians never noticed that it stunk in their city. Now, behold! they are all up in arms against this pretended infection. Who is to blame? Those incorrigible gabblers—the newspaper men. For a trifle, M. Alphand would be willing to say that it is we who are malicious enough to stink, for the pleasure of giving trouble to the authorities. For the past week it stunk every evening in my quarter, and it stunk strongly. One evening, in particular, it stunk so that I found myself compelled to shut my windows, and then it only stunk the more. On my honor! yesterday morning I had an article to write; I am in the habit of entertaining our readers with all the subjects that interest me, and just at the time when they interest me, and, as it stunk in my quarter, I immediately said, with my usual *bonhomie*, 'Oh, my children, how it stinks in my quarter!' No, you can not imagine how it stinks in my quarter. This phrase is my witness that I did not ask myself, before uttering this cry of suffering, whether M. Andrieux had made an arrest the night before, nor even whether M. Andrieux was the prefect of police. I said, it stinks, because it stunk, with the ingenuousness of a man who holds his nose, exclaiming, 'My God! how it stinks!'"*

The war of words between the public and the officials is still going on, and is becoming more virulent. At the session of the Conseil Général of October 26th, M. Raspail is reported to have made "a furious attack on the prefect of police, in reference to the factory at Les Hautes-Bornes, the worst of all the factories surrounding Paris, which had been already closed by M. Léon Renault. In spite of M. Voisin, this factory was reopened, thanks to the influence of M. Léon Say, a friend of M. Pauville, the new owner. The papers drawn against this establishment are flawless. Workmen refuse to labor in summer in its vicinity, and those who do work there are seized with vomiting. In place of closing this pestilential center, it is allowed to grow larger. And this is the history of the other depots and ammonia-factories in the suburbs.

"These bastilles of infection," says M. Raspail, "must disappear, and they will disappear, I assure you, in spite of all possible protection."†

This paper is already too long. I have had in its preparation but one object, viz.: to demonstrate that some of the nuisances existing in New York continue to exist, not on account of the ignorance, incompetence, or negligence of officials whose duty it is to abate them, but because there arise in connection with their suppression certain vast problems which are not yet solved anywhere in cities of equal size with this. And these problems do not lie on the surface, but only con-

* "Lancet," October 16, 1880, p. 639.

† "Figaro," October 27, 1880, p. 5.

front the theorist when he applies himself to practical work with personal responsibility, and he begins to find that the means at his disposal are inadequate to the results expected from him.

CEREBRAL LOCALIZATION; OR, THE NEW PHRENOLOGY.*

By HENRY DE VARIGNY.

"WHEN the one who listens does not comprehend, and the one who speaks understands as little, you have metaphysics," says Voltaire. Taking this as a true definition, we may say that there has been, and yet remains, much metaphysics in the treatment of the functions of the brain. But the difficulties in cerebral physiology are great. There is divergence of hypotheses, the facts themselves are not settled, and contradictions abound. The foundations of the science are yet deficient. But it does not follow that experiments are useless. For half a century important researches have been carried on; and more recently facts have been discovered to which we would here draw attention.

From an anatomical point of view the brain is composed of two symmetrical halves, right and left, united by a voluminous commissure, which probably puts into communication the homologous parts of the two hemispheres. Each hemisphere consists of a central mass, with its envelope of convolutions. The central mass, partially separated from its outer covering by the lateral ventricles, is composed of two round bodies, formed of gray nerve-cells—the active part of the nervous system. The office of these rounded ganglia seems to be to strengthen the impressions that come from without, or from stimulated parts of the brain itself, and they may take part in automatic actions. They are in relation, on the one hand, with the spinal cord, and perhaps, more or less directly, with most of the motor and sensitive fibers of the body; on the other hand, they are connected by fibers with the gray matter which is spread out in layers over the convolutions of the brain. In other words, the nerve-cells forming the periphery of the convolutions give out white fibers, which penetrate the central ganglia, probably connecting themselves with their cells. From these cells other fibers proceed toward the cord and extremities of the body. The central masses are on the line of the cerebral fibers between their origin in the gray cells of the convolutions and their termination in the cord and body generally.

* Translated and abridged from the "Revue des Deux Mondes" by Miss E. A. Youmans.

This anatomical arrangement seems to indicate that the peripheral substance, and not the central mass, is the point of motor stimulation and the seat of sensitive impressions. It is everywhere admitted that the brain is the organ of thought and will; but for a long time it was believed that the central mass was the important portion, and the convolutions were disregarded. Hippocrates thought they were only a gland. Malpighi and Vieussens thought the same. Ruysch, from their vascularity, considered them as a simple sanguinous network, and Boerhaave and Haller adopted this conclusion. Vic d'Azyr was the first to examine their structure; then came Baillarger, Ehrenberg, Purkinje, Meynert, Luys, Betz, and Charcot, who revealed their precise anatomy. As to their physiology, Gall taught that intelligence is a function of the convolutions; Desmoulins added that the degree of intelligence is in proportion to their number and depth; and Broca, taking the ideas and facts of Dax and Bouillaud, announced the first discovered localization—that of articulate language in the third left frontal convolution.

In 1870 two German scientists, Fritsch and Hitzig, passed a current of electricity across the head and behind the ears of a living subject, which caused movements of the eyes. They referred these movements to stimulation of the gray matter of the convolutions, and set about the verification of their hypothesis. From their experiments they drew the three following fundamental propositions: 1. There are in the head convolutions that may be excited by electricity, and this excitation is followed by the production of determinate movements depending upon the point excited; other parts being excited without producing movements. 2. The points, which under stimulation induce action in such and such muscular groups, occupy a very limited portion of the cerebral surface. 3. The extirpation of such a point of the surface, known to be a center of distinct movements, paralyzes these movements.

The theory of cerebral localization assumes as proved that there is in the brain a peripheral portion devoted to the production of movements—a motor region; and another where stimulation is not followed by movements—a non-motor region. It further assumes that the motor region may be subdivided into a certain number of small tracts, definitely circumscribed, each of which presides over the movements of a certain muscular group and this group alone. Ferrier, starting with these conclusions, proceeded with the research, and seems to have established—that the convolutions, in man as well as in the lower animals, may be separated into three regions: the anterior, devoted to intellectual functions; the middle portion, charged with the motor innervation of the body; and a sensitive region where are received the impressions made upon the sense-organs by the external world. To show how Ferrier reaches and justifies these conclusions is the object of this article.

Two methods of investigation are open to the physiologist—the experimental and the clinical. In the order of time, the first and the most practicable is the experimental method, which consists in observing the brain through openings in the skull and exciting the convolutions or removing them according to the end proposed. This method is applicable only to animals; and the monkey, from the likeness of his brain to that of man, is best suited to these investigations. But experiments upon other animals are very useful. They show the homologous regions in different cerebral types; and the inequality in relative importance of the central masses, the region of automatic functions, and the convolutions, the region of the will. The great advantage of this method is that the operator can repeat the experiments indefinitely upon all sorts of animals, varying the conditions, and choosing his own time and place. Lesions can also be better circumscribed, and the autopsy can be made at will. On the other hand, animals can not tell their sensations, and we have to judge as best we can as to affections of the intellectual and sensational regions. And the preliminary operations may cause general symptoms that mask the phenomena to be studied. Still, this method is in merited favor, and it will yet yield answers to many questions if we know how to put them.

All the processes of experimenters may be reduced to two categories, according to their effects upon the functional activity of the convolutions. These are irritating lesions and paralyzing lesions. Irritating lesions provoke spasms when applied to the motor region, subjective sensations when applied to the sensitive region, and delirium when they affect the intellectual region. Paralyzing lesions in the motor region paralyze the normal action, and in the sensitive and intellectual regions bring on anæsthesia and mental depression. But this division applies only to immediate results, for it is not rare to see a lesion, whether experimental or in clinic, provoke symptoms of irritation in the beginning, followed by paralytic symptoms, and reciprocally.

Experiments that produce prompt paralyzing effects are more numerous than those which excite the functions of the convolutions. But the most preferable one, and that adopted by Ferrier, is the method of limited ablation. By it lesions can be more circumscribed, it affords a sure means of control, and hence it has come largely into use. Electricity is the only process for exciting the functions to greater activity; and since it has been much opposed, and is the sole support of the theory of cerebral localization, we must defend its legitimacy.

It may be remarked that the convolutions of the brain are in the form of long, round, gray swellings, separated by furrows. Each of these swellings has a direction, relations, and a situation peculiar to itself, and identical for all animals of the same species; and the princi-

pal ones have their homologues in all animals. They have also their special names. When the excitant is moved about over the different convolutions, the existence of the motor zone is made manifest by the successive movements of the animal; the sensitive zone is known by signs of sensation, while the indications of an intellectual zone are not thus positive. Observe what passes when we irritate the so-called motor region. We excite a certain point of the convolutions, and a movement is produced. Groping about with our electrodes, we find the effect limited to a small tract where at all the points the same movement is provoked, and that alone. Next to this zone, we can in the same way find the limits of others presiding over other movements. The influence appears greatest at the center of the zone: exciting the periphery sometimes produces a light supplementary movement belonging to a neighboring zone. The special centers or zones being very near together, our means of electrizing them are not perfect enough to prevent a slight diffusion of the current into neighboring centers and faintly exciting them. To get precise separate effects we must excite the center of the special zone.

As the same movement invariably follows the stimulation of a special center (the name of a special zone), we conclude that the center in question has charge of this movement, and, as a great number of these centers, placed side by side, preside over most of the movements of the body, we infer the existence of a motor region of the brain, the seat of voluntary control of the body. But, since, as the galvanometer shows, the electricity is diffused over neighboring centers, what right have we, it may be asked, to assert that the movement observed, when a certain center is excited, is due to that excitation, when neighboring centers are also excited? We reply that to these facts we can oppose other facts. On removing the electrical conductors scarcely a centimetre, we excite perfectly definite unlike movements, although the current is diffused as before. Why are not the movements last produced the same as those observed at the first position? Why such distinct localization in spite of diffusion? Although the occurrence of diffusion is proved by means of sensitive apparatus, it is physiologically insufficient. Besides, it can be prevented by proper precautions.

Again, it is asked if there may not be such a thing as diffusion beneath the surface? This is a grave question, for, under the motor region, there is a large ganglion containing motor fibers going to the muscles. If the current diffuses downward as far as this ganglion, we can not assume that the convolution alone is excited. There are three answers to this objection: 1. The excitation of the convolutions nearest to this ganglion gives the least results; sometimes no movement at all. Unless we admit that the effects are directly as the resistance, which is absurd, downward conduction can not be affirmed. 2. Braun has demonstrated that a section of the white fibers below the excited points, interrupting the physiological continuity, does not

arrest electrical conduction sufficiently to prevent movements. 3. Ferrier has shown that the direct excitation of this ganglion produces a general muscular contraction of the other side of the body, and not special isolated movements. So that we again conclude that, though electrical diffusion toward the corpus striatum (the name of the ganglion in question) may exist, it is physiologically insufficient.

But, it may still be asked if electrical diffusion does not excite the white fibers interposed between these convolutions and the ganglion beneath. This objection borrows a character of probability from the slight thickness of the layer of gray matter of the convolutions, and also from the alleged unexcitability of the gray substance, which has been proved in the case of the spinal cord, but conclusive proof in regard to the brain is yet wanting. Many physiologists claim that these cells are only excitable by the will. For the theory of motor-centers they substitute that of psycho-motors. Reserving this discussion for another time and place, we may say that, whether we excite the cells or the fibers that arise from them, the result is the same.

All stimulation, whatever its nature or origin, acts upon a nerve according to its functions. Excite a motor nerve at any point of its course, and you produce movement; excite a sensory nerve, and the subject will feel a sensation which will vary with the nature of the nerve. Compress the eyeball, you excite the optic nerve and get the sensation of light; auditive nerves give sensations of sound, and so for all the nerves of special or general sensibility. If, then, in the brain we excite the motor region, the origin of the motor nerves is irritated, and we get movements; excite the sensitive region, and in place of movement we have sensation owing to the connection of these nerves with sensitive cells. So that the electrization of the gray matter of the convolutions acts in the same way as the electrization of a nerve on any point of its track; the only difference is that in one case we excite them at a point near their origin. From the anatomical relations that exist between the white fibers and gray cells, we infer that the cells play the rôle of center to the nerves.

We come now to the details of Ferrier's experiments. Ferrier operated chiefly on monkeys, because in them the will is in the ascendant, while in lower animals automatism preponderates. As the result of his experiments, he affirms the existence of three zones—the intellectual, motor, and sensitive—into which the surface of the brain can be divided. The one best known, and to which least objection has been made, is the motor zone. In passing the electrodes over its surface, we soon find the little, well-defined centers that preside over particular groups of muscles. Under the microscope there is seen at these points a limited mass of large cells, called *nests* by Betz. The functions of these centers are best shown when they are electrized at the central point, the current being then less likely to spread, and so produce more complicated movements that mask the true function of

the center under experiment. Here electricity provokes movements of the leg on the opposite side, owing to the cross-action of the hemispheres. It moves as if to go forward; or the movement may be limited to the foot, or even the great-toe. Sometimes the motions are still more complex, and involve many muscles, as if the animal would scratch its breast or press against it some object which it had taken from the ground. Again, it is the arm, forearm, or hand that moves in various ways, and to different ends; sometimes there is a combination of movements, like those required for swimming or prehension; the fingers may lock together with force, as if to retain an object, or extend themselves with a lively movement, as if to scatter something. It is probable that, if our instruments were more perfect, we should find in each center a number of subordinate centers for the execution of single movements, or the moving of a single muscle.

The general idea of the relations of the brain and spinal cord is that the brain commands and the cord obeys. The brain requires such or such a movement, and the cord, working unconsciously, coördinates the elementary and individual movements required to produce the desired effect. Electrizing the centers is the same as issuing an order to the cord, not of directly exciting movement.

Monkeys being difficult to obtain in our climate, to satisfy the constant needs of experiment, Ferrier operated upon dogs, jackals, Indian pigs, rats, pigeons, frogs, fishes, anything that was going. These experiments fully confirmed the results otherwise obtained, and showed, besides, that the action of the hemispheres is of less importance as we descend in the animal scale, while automatism rises.

Ablation of a limited portion of gray matter of the brain leads to the same conclusions as electrization. It produces paralysis, and monkeys rarely or imperfectly recover from these lesions, while inferior animals, as the rabbit and Indian pig, recover; thus showing that the voluntary centers are more important in monkeys than in lower animals.

Such are the facts on which we base the existence of a motor region in the brain. Putting aside all questions of interpretation, it is undeniable that there is a region in the brain where stimulation produces movements varying with the zone or center excited.

Behind this region we find the sensitive centers which receive impressions made upon the sensory nerves, and form perceptions from them. As the terminations of the nerves of sensation are specialized, in exciting the centers we produce subjective sensations, like those caused by cerebral maladies, in which the intellect refers to the outward world the origin of sensations, of which the cause is in the brain; and, whether voluntarily or by reflex action, the animal operated on by electricity shows by evident signs the nature of the sensations he experiences. By means of counter-verification we determine the exist-

ence and topography of a certain number of centers which Ferrier has studied with great care.

Take, for example, the visual center: its stimulation caused disordered reflex actions, indicating unpleasant visual perceptions. This alone is insufficient proof; but we can control the region in question by ablation, which brings on unilateral or bilateral blindness, according as we operate on one or both of the visual centers. Stimulation of the auditive centers, in the same part of the brain, provokes movements of the ears, eyes, and head, showing astonishment or terror, just like those caused by a violent and unexpected noise. Ablation causes deafness; the animal remains indifferent to all sounds. Excite the centers of touch, and the signs indicate disagreeable or painful tactile impressions. Ablation brings on complete anæsthesia of the same parts; you may prick, cut, and bruise the animal, and he remains insensible.

Some experiments seemed to indicate the existence of centers of taste and odor, but it is difficult to trace their limits. They are intermingled like the gustative and olfactive sensations. Electricity causes movements indicating unpleasant tastes and odors, and extirpation of the parts ends these sensations. The animal will respire odors, or taste savors that in the normal state would make him fly about the laboratory, and it all passes unperceived. Still more hypothetical are the centers of the organic needs of hunger and thirst, and more yet those of sex, but Ferrier's arguments are strong in favor of their existence.

The presence of a third, or intellectual region, is proved, as far as it can be, by experiments on the lower animals. It is difficult to understand the mental action of a dog, Indian pig, or even of a monkey. Ferrier observed numerous facts tending to establish the intellectual function of the anterior region of the brain. Electricity could hardly be employed in these researches; but ablations, when performed with caution, brought on notable changes in the habits of animals. The monkeys chosen by Ferrier were remarkable for their vivacity and intelligence, prying about right and left, and observing everything. After the operation they became stupid and apathetic. But these indications are not convincing. The clinic alone can decide whether physiology sustains the doctrine of cerebral localization.

We know in what the clinical method consists. Applied most often to man, it amounts to this: to observe the symptoms of cerebral disease, and at the autopsy to connect the lesions, discovered by the naked eye or the microscope, with the symptoms, as cause and effect. It is true that in cerebral pathology there is great difficulty in separating the essential from the accidental, and distinguishing cause and effect among a plurality of causes. Besides, it frequently happens in cases of cerebral disease that at the autopsy no appreciable lesions can be found. The question is still further complicated by the solidarity

that binds together the different parts of the cerebro-spinal system and which makes it probable that a simple local trouble will produce general functional perturbation. The brain is like a complex machine, in which, if a screw loosens, or a nut gives way, or a rod bends or breaks, at once all goes wrong. It is not that the screw, nut, or rod in question is the immediate cause of the movements of the machine, but that the failure of these accessories may, for the moment, produce accidents as grave as would be caused by disturbance in much more important parts. Again, cerebral lesions tend to spread and become general. And yet, we have to accept the lesions caused by disease, for we can not produce them at will.

With these reservations, the clinical method is still of the first importance. By means of it we verify in man the hypotheses of experiment, and assure ourselves of the existence of the intellectual and sensitive regions of the brain. Neither medicine nor physiology opposes the use of the clinical method in cerebral localization. But only circumscribed lesions that have little or no tendency to become general, or to act at a distance by compressing the brain, or otherwise, can come to the aid of our theory. When there is a lesion of the cortical region of the brain which fulfills these conditions, the resulting symptoms may be of two orders—either stimulative or paralytic of the true function. These are the two opposed symptoms that we produce experimentally by electrization and ablation of the substance of the convolutions. It goes without saying that the symptoms vary with the locality of the lesion : the intellectual region gives delirium ; the motor region, spasms ; the sensitive region, subjective sensations. The symptoms of functional paralysis are also diversely represented by mental feebleness, motor paralysis, and anæsthesia limited to one sense. A lesion frequently presents both orders of symptoms, which succeed each other, or alternate, according to its nature. This fact is as important as the division of the symptoms into two great classes. We will now consider the facts in the same order as before.

The middle region of the superior face of the brain appears to be the motor region. In fact, limited lesions of this region bring on marked troubles in the motor innervation of the body, such as monoplegia, or limited paralysis, or equally limited spasms. Putting aside those cases where the lesions cause general trouble, and regarding those where the symptoms are limited, we come at a constant relation between certain lesions and certain troubles. In ocular monoplegia, the eye can not be controlled by the will. Brachial and crural monoplegia are more frequent ; sometimes a single member, arm or leg, sometimes both ; but successively, because of the extension of the lesion to both centers, which are near together. In this case the lesion advances slowly and invasively ; at the autopsy we can often appreciate the differences of age of the extreme points of the diseased spot. Not far from the brachial and crural centers is the center that

presides over the muscles of the face. As before, this center may be affected alone or simultaneously with the other. It depends upon the nature of the lesion whether the invasion is sudden, or slow and progressive, ending in feebleness rather than in paralysis. The proximity of the brachial and facial centers explains their apparent solidarity in the normal state, as shown by the grimaces that often accompany vigorous use of the arms. It seems as if the second center were stimulated by the activity of the first. We close our enumeration of the centers which the clinic has proved to exist by reference to the center of articulate language, discovered long ago by Broca, which attends to the coördination of phonetic movements.

We have seen that lesions of the motor region of the brain may be manifested by spasms as well as by paralysis. These monospasms have been long known, but it was Hughlings Jackson who first attributed them to lesions of the motor region of the brain. Prior to this they had been described by Bravais, but he did not seek for their origin or signification. They are localized convulsions, or partial epilepsy, and Hughlings Jackson thinks they are due to nervous tension. Any new excitement added to those already stored up will produce discharge or spasm. Like monoplegia, they may be limited to an arm or leg, or even the face ; but these phenomena are seldom noticed, and we have few observations upon them. When the spasm involves several parts of the body, it always begins at the same point and follows the same order. Dr. Maragliano has made a very interesting study of partial epilepsy, and explained its causes and signification. Both monospasms and monoplegia indicate the same localization of power.

The sensitive region is found, by experiment, behind the motor centers. While limited lesions of this region often manifest themselves externally as circumscribed anæsthesia, it sometimes happens that they remain latent when they are seated on only one hemisphere. There is no sign of pathological perturbation, and in this case we seem forced to admit functional substitution, or the possibility of the regular action of two sensitive, homologous regions, notwithstanding the absence of one of the two corresponding cerebral hemispheres. What does this signify? Must we abandon the doctrine of localization as regards the sensitive centers? A single center suffice for the two parts of the body? This anomaly is probably due to insufficient observation. Disease of the cerebral centers may give no further symptom than enfeebled sensibility, which might pass unperceived. Lesions of the motor region often result not in total paralysis but in slight paralysis—a feebleness and not an abolition of the functions. But there are cases where lesions of the sensitive region are accompanied by less equivocal symptoms, and it is from these that we affirm localization.

Symptoms may be of two orders, according to the nature and the phase of the disease : symptoms of excitation, which produce subjec-

tive sensations responding to nothing external, and symptoms of anæsthesia manifested by an abolition of the perceptions belonging to the affected part. These two classes of symptoms may also alternate in the same disease, as in the motor and intellectual regions.

A characteristic case, confirming this theory, is that of a child who fell on his head and buried a portion of the parietal in the surface of the brain. He became blind in the eye of the opposite side. He was trepanned, and the blindness ceased immediately. Soon inflammation arose at the wounded part; blindness returned and lasted till the inflammation disappeared. Compression of the visual center, first by the bone and then by the products of inflammation, was the evident cause of this intermittent blindness. Other cases establish the possibility of abnormal stimulation of the visual center.

The centers of hearing, taste, odor, and touch are localized in the same way, and, if the observations are not very numerous, they make a strong presumption in favor of the localization actually adopted. It sometimes happens that several centers are affected at the same time. In these cases, if the lesion is an irritating one, there occurs from time to time a simultaneous discharge producing a singular mixture of sensations. One such patient, observed by Ferrier, said that he had the sensation of a horrible odor and green thunder. We admit that the clinical arguments in favor of the localization of the sensitive centers are not so numerous or conclusive as could be wished. But only lately have they been sought, and each day brings its contribution, which, considering the rarity of limited lesions of the brain, can not be very considerable.

The localization of intelligence in the frontal region of the brain was thought of long before our day. Gratiolet used the expression *frontal races* for intelligent races; and those of least intelligence have been called *occipital races*. The frontal region is greatest in man along with the predominance of reason and logic, while in women, who are dominated by their sensibilities, the occipital region prevails. We may cite to the same point the researches of Bordier on the skulls of assassins, of Luys on the brains of fools and idiots, of Bénédikt on the brains of criminals, of Lombroso on the characters of habitual criminals. Their conclusions are analogous, and favor more than they oppose the popular idea.

But these arguments are not precise and positive. Happily there are others more scientific and more conclusive. Take the celebrated crowbar case, where a young man, who was blasting, had a pointed bar of iron about three quarters of an inch in diameter and weighing three pounds, driven, by a sudden explosion, upward through his head. It entered at the angle of the under jaw, passed behind the nose and eyes, penetrated the skull, and cutting the cerebral substance of the frontal region passed out at the top of the head, above the forehead and to the right of the median line. The wound was frightful. All one part

of the brain was disorganized, without counting the multiple fractures of the skull and face. He was alone, but, in less than an hour after the accident, without help, he walked to the surgeon's, went up the steps, and related the circumstance clearly and intelligibly. He recovered, but died of epilepsy some twelve years later. His physicians and friends observed that his character and intelligence changed notably after the accident. From being intelligent and active he became capricious and unsteady, and had to retire from his post of overseer. Analogous cases to the same purpose might be cited, but we have no space. We need new facts, but those we possess strongly favor the theory of Fritsch, Hitzig, and Ferrier.

We have passed in review the experimental and clinical arguments in support of this theory ; and there are others of not less importance drawn from pathological phenomena. But we have no space for their consideration.

M. Brown-Séquard has shown the greatest hostility to this theory. His chief argument is that lesions and symptoms are not coextensive. An insignificant lesion causes general trouble ; a considerable lesion remains latent in the matter of symptoms. This is true, but it is the exception ; whereas he ought to show that it most frequently happens. The real question is, Does the seat of a lesion signify nothing, and may we have identical symptoms with two very different lesions ? And we have demonstrated that this can not occur. The facts cited in opposition to the theory of Ferrier may be embarrassing, and at present inexplicable ; but such facts would be far more abundant if we admitted the theory of M. Brown-Séquard.

Again, there is the theory of Vulpian, who thinks that the stimulation of the gray cells by electricity is not possible. For motor centers he substitutes psycho-motor centers. In his view, stimulation of the convolution acts, not on the cells, but on the white fibers which proceed from them. But his mode of interpretation does not alter results, nor set aside the centers.

Goltz made a curious experiment, showing clearly the office of the centers. He took two dogs of the same species, one having the education common to all dogs, and the other some supplementary accomplishments, and among them that of giving the paw. In both dogs he removed the center which presides over the movements of the fore-paw of one side—the one given by the knowing dog. They soon recovered, and could run about. Running is a reflex act, that does not require the intervention of the centers. But, while the learned dog could use his legs, and go and come, he could not give his paw. This was a superior, voluntary act, which could not be performed in the absence of the corresponding center. It is in this differentiation of the organs of voluntary activity from those of automatic activity that we find the explanation of so many singular facts which at first sight seem to contradict the theory of localization.

It is undeniable that there is yet much to be done in this domain. But the results obtained by Ferrier are so encouraging that we hope this new way of studying cerebral physiology will be followed and explored with more care than ever.

A PIECE OF COAL.

By R. S. CALVIN.

A LUMP of coal—black and grimy, and repulsive to sight and touch as it is—is, perhaps, not the most promising subject that could be selected for Sabbath-evening reflections. But, if there are sermons in stones, why not in coal? The black thing, that we would rather not handle when we have any proper regard for cleanliness, becomes an object of interest when we find it exerting energy in the engine-furnace or shedding warmth and radiance around our household hearth. It becomes an object of yet greater interest when we come to learn its wonderful history; for every common bit of coal that we are accustomed to see has a history with which is wrapped up the story of one of the most interesting and critical periods in all geological time. It is the lessons and promises of this far-off history of the coal that constitute the theme for to-night.

Fifty years ago an attempt to tell the history of the coal would, no doubt, have seemed, to all but a very few, not only hopeless, but absurd. Since then the methods of questioning Nature and making her tell her own history have been so much improved, and have been, withal, so energetically applied, that very much, which our grandfathers would have set down as past finding out, has become the mental property of every well-instructed schoolboy.

There are many different kinds of coal, and coal belongs to many different epochs in the world's history, but that which we find in the coal-fields of Iowa and Illinois may be taken as the type of what is usually understood, the world over, when coal is mentioned. Let us fix our attention on a piece of such coal. To extort from that expressionless thing any facts bearing on its history would seem discouraging enough. We may look at it just as long as we please; we may break it to pieces with the hammer and examine it bit by bit, and it is altogether likely that we will be left just as wise and just as hopeless as when we began. Pass it over to the chemist, and he will tell us that it is made up of combustible matter of which so much is fixed and so much volatile, with a certain percentage of earthy substances and traces, perhaps, of ever so many elements that we never heard of before. The information is interesting—in many respects it is of the highest importance—but for the purposes of the present discussion it amounts,

after all, to telling what men have more or less clearly perceived for the last thousand years or more, that *coal will burn*. By proper manipulation we may obtain thin slices of coal suitable for microscopic examination, and in this way may demonstrate that a large proportion of it is composed of what seems to be crushed and flattened vegetable cells. You are all aware that plants of every kind are made up of little microscopic units called cells, and that these cells differ so much in markings and other characteristics in the different groups of plants that one group may often be distinguished from another by the study of the smallest microscopic fragments. Now, in the coal itself, and often in the ashes that remain after combustion, it is possible to

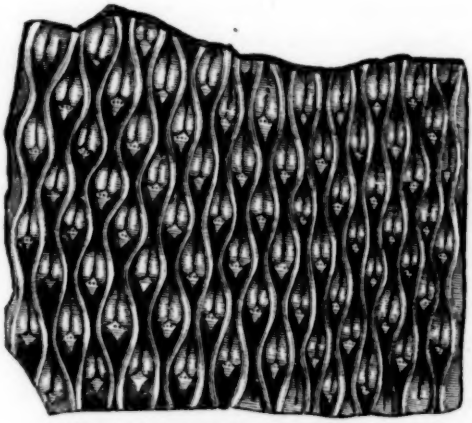

FIG. 1.—LEPIDODENDRON MODULATUM.

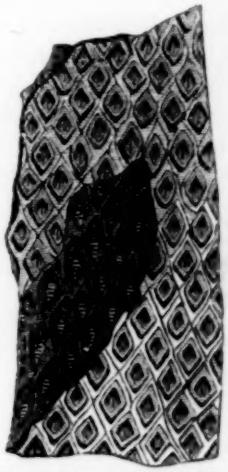

FIG. 2.—LEPIDODENDRON DIPLOTIGIOIDES.

recognize the peculiar cells that characterize certain great divisions of the vegetable kingdom; and, as this method of study is extended, we are gradually led to the conclusion that coal has somehow been derived from plants. Let me say, however, that to reach a conclusion and to entertain an opinion on a question of this or any other kind, where matters of fact are involved, is too serious a thing to be accomplished lightly. The color, hardness, and other physical properties of coal, together with the fact that coal-beds are often buried under hundreds of feet of rock and soil, may well make us hesitate before accepting any such conclusion. Let us attempt the solution of the question in another way: All around the globe, in the middle and higher latitudes, are beds of peat. Now, peat, especially when well pressed and dried, presents many very suggestive resemblances to coal. But there is not the slightest difficulty in determining how peat is formed, for we may see the process going on before our eyes. We can study every stage in the process, from the living and dead plants growing and accumulating in the marsh at one end of the series, to the completed peat-

bed awaiting only the proper manipulation to be converted into useful fuel at the other. That peat is formed of plants, and largely of plants that accumulate just where they grow, can be no longer questioned.

In the swamps and bayous of the moist regions of the South, pure vegetable matter, having the appearance and properties of peat, may often be found in the very act of accumulation. It frequently occurs in immense beds, and it requires no trained observation to see that, in addition to the remains of the ordinary low marsh-plants, it is made up of the ruins and refuse of swamp-loving forest-trees. Now, all about the flanks and spurs of the Rocky Mountains, with greater or less intervals, from New Mexico to far beyond the northern limits of the United States, there are found beds of coal of peculiar quality. This coal is covered up with hardened mud containing shells and bones of aquatic animals, and everything about it suggests that the coal-making material was somehow sunk beneath the waters of an old lake, and was buried under the gradually increasing bed of mud with which the old lake-basin was finally filled. But the point of interest is this: that in many places the Rocky Mountain coal has reached a stage of decomposition not so very much in advance of the humus and peat of our modern swamps and bayous. We might, indeed, hesitate about calling some portions of it coal at all—for the original structure is almost perfectly preserved—yet it must be admitted that for the most part the decomposition has advanced far enough to produce an article that deservedly ranks as coal. In the light of what may be observed going on in every favorably situated swamp to-day, the source of the material and the method of accumulation of the Rocky Mountain coal can hardly be doubtful. I need not weary you by leading you step by step through all the known coal-fields that illustrate the different stages in the process of coal-formation. It will be sufficient to say that a perfect gradation may be traced from the lignite, as it is called, of the Rocky Mountains to the purer and more perfect coal of the Mississippi Valley; and so, even setting aside the internal evidence of our Iowa coal, we are compelled to believe that it is simply one of the terms of the same series to which the lignite and the peat belong, and that the initial term of that series is to be looked for in the living vegetation of modern marsh and forest.

FIG. 3.—RESTORATION OF A LEPIDODENDRON.

The conclusion is interesting, though to an intelligent audience it could hardly be called unexpected. The method of reaching it is worthy of notice, and points some important lessons. Though the

coal of Iowa was accumulated in what is called the Carboniferous age —an age of the world that is immensely distant from the present, infinitely so, indeed, as we count time—yet the processes of Nature were the same then as now. That old world was, in every essential particular, the same world that we know, and was governed by precisely the same laws that control it to-day. What is true of coal is also true of every part of the geological record to this extent: that all the strangely fascinating history recorded in the rocks must be read in the light of what may be seen actually taking place now. It has become a maxim of geology that, if we would know how anything was done in the past, we must study the method in which Nature is doing that very same thing in the present. Following these suggestions a little further, we are led from the study of this particular side of the history of coal, through similar studies, to the grander and more significant

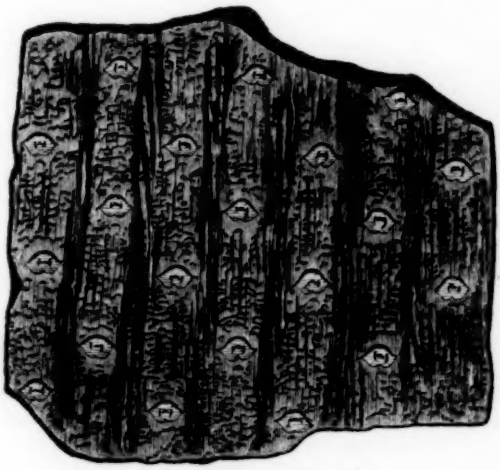

FIG. 4.—SIGILLARIA RETICULATA.

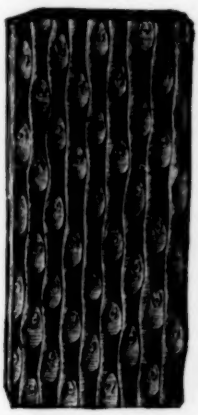

FIG. 5.—SIGILLARIA GRÆSERI.

generalization that the laws that govern the world have been the same for all time; that the laws of matter were imposed upon it as long ago as that old, old nebula of which you have heard, and that there has been no occasion to repeal the old or enact any new laws since.

But we must get back to our coal, and pursue the series to which it belongs a little further. The product of our Iowa mines is one of the terms, as we have seen, in that interesting series, but it is not the final term. We may start with bituminous coals, like those of Iowa, at Pittsburg, for example, and working our way across the State of Pennsylvania toward the foot-hills of the Alleghanies, we will cross one of the grandest coal-fields in the world, and at every stage of progress will pass from more to less bituminous coal, until by almost imperceptible gradations we will find ourselves in the region of anthracite. Anthracite, then, is only another term in the coal series; it

represents only a more advanced state of carbonization than bituminous coal; the difference seems, in some way, to have been brought about by the play of the gigantic forces that gave rise to the mountains, for in all the region disturbed by those forces—in all the region in which the rocks have been folded and crumpled and changed—the coal is anthracite, and anthracite rarely occurs in other situations.

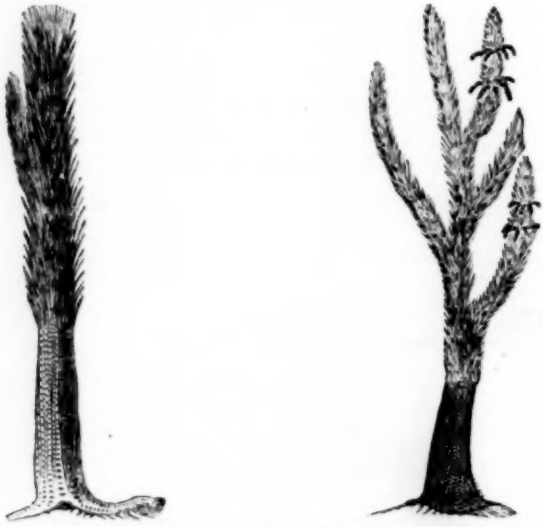

FIG. 6.—RESTORATION OF SIGILLARIA.

Passing over the Alleghanies, we find the disturbing forces have acted with even greater energy on their eastern side, and accordingly in many places the only thing that bears any resemblance to coal is a black substance more perfectly carbonized than anthracite. It is to this substance that we are indebted for the universal use of the lead-pencil, for it is nothing less than black-lead or graphite. And here in a measure we lose track of our series; we find no gradations by which to trace it further, and yet it is as certain as anything can be that graphite is not the ultimate term, for in it we have not yet reached the perfection of carbonization. That perfection is finally reached, however, in the gem of gems, the diamond, the only example of absolutely pure, crystallized carbon. Though the steps between graphite and diamond are not known, we feel sure that those steps, or something corresponding to them, have been taken some time, and that diamond, graphite, coal, peat, and growing forest, all belong to the same series, and represent different conditions of the same thing. And so our piece of coal acquires interest and dignity, and becomes, altogether, a thing not to be lightly despised, for, in addition to its own real worth, it enjoys the advantage of being able to claim kindred with the aristocratic Koh-i-noors of Golconda.

But how are the great ledges of rock above the coal to be explained? Let us see. The rocks in question are very often sandstone, and if we examine them carefully we find that they are spread out in layers, that they contain the remains of many marine animals, and that the surface of a very large number of the layers shows signs of having been washed by waves. With the exception that they are somewhat harder and the organic remains belong to more old-fashioned types, these rocks are exact duplicates of the widely spread layers of sand that the ocean is piling along all our shores to-day, and contain the clearest evidence that they have been swept into place by the waves of some old sea. But how came the coal beneath the sea? That is an important question, and the full answer to it would show that no truth is more plainly taught by all the records of the past and present than that the earth's surface is a very uncertain and unstable affair. You will find your answer to the question on the shores of Greenland, where the coast, for hundreds of miles, is slowly sinking into the sea; the result in historical times being sufficient to convert old marshes into shallow bays over which sands are swept by each returning tide. You will find your answer along the coast of New Jersey, in the buried forests with their prostrate trees and upright stumps, all carried down in very recent times by the subsiding land just within reach of the sea. You will find your answer in the buried forests of the delta of the Mississippi. You will find the same answer in a hundred other places. Large areas of land in different parts of the world are gradually subsiding, and large areas in the Carboniferous age sank down in the same way. Each coal-seam is the record of peat-bog and forest; the overlying rocks record a period of submergence.

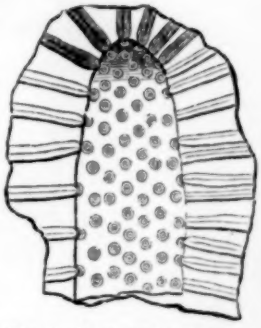

FIG. 7.—STIGMARIA FICOIDES.

But the movements in the earth's surface at present are not all downward; there are, perhaps, as many cases in which the land is rising. During the Carboniferous age, the same thing was true, and it often happened that the area that was carried beneath the sea was, in time, reëlevated, and became the platform on which other forests and peat-bogs renewed the work of coal-making. Thus it is that in many coal-fields we find a number of seams, one above the other, and thus it is that we have registered in the coal-beds of Nova Scotia not less than seventy-six distinct upward and downward movements of the surface. The sinking of the old marsh beneath the sea might seem to involve the loss of all the materials that had been accumulating during periods, perhaps, for which years would furnish no adequate unit of measure, and yet this very movement was essential to the preservation of the great magazines of energy on which human progress so much depends.

I have already referred to it as a matter of considerable interest, that a large proportion of some coal is made up of crushed vegetable cells; but that is not all—a still more wonderful fact remains to be noticed: The microscope, prying into all the little corners and secret places of Nature, declares that the pitchy parts of most bituminous coal are composed almost entirely of little spherical bodies, microscopic in size—so minute, indeed, that hundreds of them together might well be disregarded as "the small dust of the balance"—and yet so numerous that great coal-seams often appear to be made up of little else. Large numbers of them are often found huddled together in small round sacs

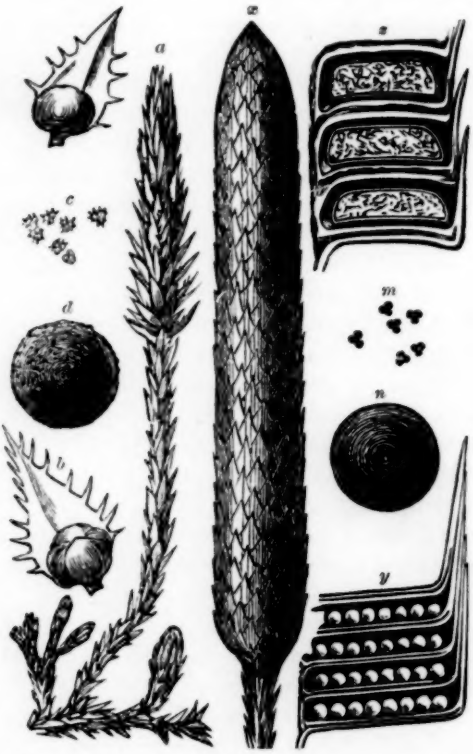

FIG. 8.—LEPIDODENDRON COMPARED WITH CLUB-MOSS: *a*, club-moss; *b*, a scale enlarged; *c*, microspores; *d*, macrospores; *x*, lepidostrobus; *y* and *z*, the scales containing spores; *m*, microspores; *n*, macrospores.

of peculiar appearance. We are indebted to the patient labor of a number of observers for the fact that the smaller granules are the spores or seeds of some plant of inferior organization, and the larger sacs are fruit-cases in which the spores were developed. The whole history of this fruit, the manner in which it was produced, its relation to the stem and leaves of the plant to which it belongs, even its fertilization and development, have all been carefully worked out with an

amount of labor that can hardly be appreciated, but with results as certain as if the actual development had been watched in the living plant.

The plants, themselves, on which this old coal-producing fruit was borne, and whose carbonized stems and leaves lie heaped up and mingled with the spores, have some lessons of interest for the student of world-history. One of the best known of these plants has been called Lepidodendron, or scale-tree, on account of the beautiful scale-like markings impressed upon the bark (Figs. 1 and 2). These markings—diamond-shaped and arranged in close-set spiral lines around the stem—are scars left by the falling leaves. Elaborately sculptured stems are found in all our coal-measures, often with dimensions indicating trees three to five feet in diameter, and seventy to a hundred feet in height. Such trees, judging from their abundance and world-wide distribution, must have been conspicuous objects in all the forest-covered swamps of the coal age. Conceive, if you can, of tall, rigid trunks, ornamented with delightful patterns of inimitable sculpture-work, rising to a height of thirty or forty feet and these dividing into two equal clumsy branches; then let each of these divide again and redivide until a number—though not a very great number—of smaller branches are produced; then clothe each of the branches with a bristling array of thick-set, lance-like leaves; let each branch terminate in a club-shaped cone or fruit from which multitudes of resinous spores, at the proper seasons, came showering down, filling the air with clouds of dust for days and weeks together, and sifting in among the roots of all the dense undergrowth with which the coal-marsh is covered—and, having drawn this mental picture fairly, you will have some idea, perhaps, of a Lepidodendron (Fig. 3).

But, if we would award credit where credit is due, we must in all fairness acknowledge the preëminent importance of another group of

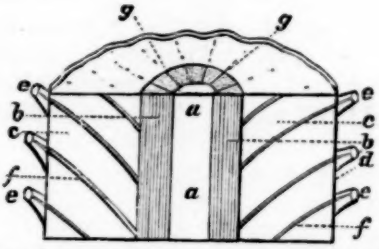

FIG. 9.—IDEAL SECTION OF A SIGILLARIA-STEM: *a*, pith; *b*, woody cylinder; *c*, inner bark; *d*, rind; *e*, bases of leaves; *f*, vascular thread running to the leaves; *g*, medullary rays.

plants to which we are indebted for by far the largest share of the coal. These plants outnumbered the Lepidodendrons in all the swamps; like Lepidodendrons, they rose to the dignity of great trees; the trunks were composed of firmer and more densely packed woody tissue; the bark was thick and rich in bituminous matter, and in some of them it

seems probable that large nut-like fruits were produced in place of spores. They are known as Sigillarias, and differ from Lepidodendrons, in addition to the characters already enumerated, in having stems less frequently branched; the stems are also longitudinally fluted like some great columns of architectural beauty and finish, and between each pair of vertical ribs are now found the leaf-scars in variable but always orderly arrangement (Figs. 4, 5, 6). Instead of at the ends of the branches, the fruit was borne in cones, resembling pine-cones, springing from the sides of the stem. The leaf-scars often resemble impressions made upon wax by the old-fashioned seal, and hence the name Sigillaria, or seal-tree. Great, somber, stiff, post-like things they must have been, as, crowding each other in all the swamps, they lifted to the sky their great, bald trunks, with scarcely any branches, and nothing worthy of the name of foliage. Perhaps we should say that the most important part of Sigillaria was really underground, for all the old coal-swamps seem to have been traversed in every direction with a perfect network of creeping subterranean or subaqueous stems, and from these arose the aërial fruiting stems that we have called Sigillaria. Such underground stems, creeping and interlacing through the peat-like humus, must have formed a much-needed foundation on which to support the tangled forest of vegetation that grew and accumulated in all the quaking, boggy marshes. These creeping stems are called Stigmaria, and were known for a long time as one of the most abundant fossils of the coal, before their relation to Sigillaria was so much as suspected. They have markings arranged something as in Lepidodendron, but when we find them undisturbed—still imbedded by the old soil in which they grew—there arise from the center of the several scars long, thread-like filaments now known as rootlets (Fig. 7).

Almost every seam of coal has been shown to rest on a bed of clay, called among miners the under-clay or dirt-bed. This clay is penetrated in every direction by fossil roots with upright stumps sometimes attached, and it requires no argument to show that it is an old fossil forest bed—the original soil in which some, at least, of the coal-plants rooted and grew. This old soil has always been known to be particularly rich in Stigmariæ with the thread-like rootlets still in place, but it was not until Mr. Binney and others discovered Sigillarian stumps arising from wide-spreading Stigmarian roots that the real relations of the two forms of vegetation were perceived and acknowledged. It is always easy to do a thing after we have been shown how, and so nothing is more common now in all the coal-measures, both of Europe and America, than to find the upright stumps and the subterranean stems still maintaining their original relative positions.

Such, in some particulars, were the Lepidodendrons and Sigillarias of the coal age. The two groups of plants differ widely in some respects, but they are connected by a complete series of intergrading

forms, and in all essential points of structure a close relationship is indicated between them. It is, however, in their relationship with modern plants that they are principally interesting. In the moist woods of New England, and farther south along the summits of the Alleghany Mountains, there lingers a group of little plants, called Lycopods, ground-pines or club-mosses, that must be regarded as the nearest living relatives of Lepidodendron. The habit of growth is very much the same; the mode of fruiting is almost identical; the little spores are produced with the same extravagant copiousness, and, being resinous, are highly inflammable. Both plant and spores—but particularly the latter—will bear long-continued maceration in water without undergoing complete decay; and so it is, in a great many respects, that our little club-mosses—rarely attaining the dignity of a

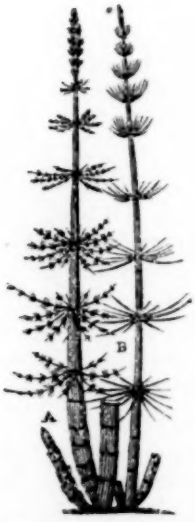

FIG. 10.—RESTORATION OF A CALAMITE.

FIG. 11.—COAL-FERN: CALLIPTERIS SULLIVANTI.

FIG. 12.—COAL-FERN: ALETHOPTERIS MASSILONIS.

foot in height—are very exact miniatures of the ancient Lepidodendrons (Fig. 8). You may then, if you please, call the Lepidodendrons and their allies gigantic club-mosses; and yet, if you do no more than that, you will fall a long way short of doing them full justice. For though in the mode of fruiting they are indeed club-mosses, and

nothing else, yet, as regards other essential structural characters, they deserve a much higher rank. Taking a section of the stem of Sigillaria, for example, and studying the arrangement of the tissues—the pith, wood, bark, and vascular bundles—we find a plan of structure that characterizes only the very highest of modern plants (Fig. 9). Apply the microscope to thin slices, and the most intimate connection with the pines is suggested; indeed, if there were only time, it might be shown that the range of relationship of these old plants extends over a wide section of the vegetable kingdom, and is of such a nature as to set them very much above their dwarfed representatives of the present woods, the club-mosses. In addition to Lepidodendrons and Sigillarias, the forests of the coal age supported many a tall pine, particularly on the uplands, while groves of reed-like calamites (Fig. 10) fringed the swamps; and the whole surface, both of swamp and upland grove, was covered with a dense undergrowth of magnificent ferns (Figs. 11, 12, 13). But the pines were not the pines of our woods, for some of them, through their broad, frond-like leaves and other characters, were allied to ferns, while all of them showed more or less decided taints of characters inherited from club-mosses, or rather the characters were inherited with club-mosses from a common ancestor. The calamites, too, were a curiously mixed-up group, and even the ferns showed a most reprehensible lack of allegiance to the fern type, since most of them united characters that do not belong to ferns at all, but are found now only separated in the palms on the one hand, and the highest flowering plants on the other. It is extremely difficult to present in few words any clear picture of the old Carboniferous forests. The stately club-mosses towering above all competitors—real monarchs of the wood—ornamented from root to crown with beautiful carvings in regular and delicate designs; the magnificent ferns whose exquisite outlines are still preserved in the roof shales of every coal-seam; the dense, dark jungles, tangled and impenetrable; the heavy, steaming, miasmatic atmosphere; the astonishing luxuriance of all the vegetation—these all are themes that claim the attention of every writer or speaker on this subject. But to my mind the prime interest centers in the composite nature of the vegetation, with all its wonderfully puzzling and intricate relationships. He must be dull, indeed, who can not see that in this significant mingling and blending of characters, the old coal forests epitomize and foreshadow all subsequent vegetation. All the structural elements were there; almost every fundamental type had a place in some of the curiously constructed plans of plant-life, and all progress in higher vegetable

FIG. 13.—COAL-FERN: HYMENOPHYLLITIS ALATUS.

organization since then has come about through the unfolding and development of the possibilities, the carrying out of the promises, and the fulfillment of the prophecies that were woven into every tissue of the old ferns and club-mosses. The types that lay latent in the oldest vegetation have simply been separated and perfected; progressive development has been gradually led along a series of intricate but constantly diverging lines that lead out and up, and finally terminate in the endless graded ranks and profuse varieties which constitute the grand flora—the grandest the world has ever seen—that annually buds and blooms, and bears its wealth of leaf and fruit for you and me, provided only we appreciate it all. Indeed, the whole world, past and present, is ours, but only so far as mind and soul can lay hold of and possess its wondrous beauty, and still more wondrous meaning; beyond that it belongs to the dull ox as much as to us.

But life has never been the exclusive property of plants, at least not since the geological record accessible to us began. Neither have plants monopolized the significant facts from which we may draw interesting conclusions regarding the laws of Nature and of being. In our study of the coal, we catch glimpses of animals that are worthy of notice. Their remains are left, along with the remains of plants, imbedded in the coal itself, or in the strata that limit the coal-seam above and below. Time will permit us to notice only a few examples. We must omit all description of the large, clear-winged insects that flitted in and out among the calamites and ferns, as well as of the curious spiders that laid snares for them in all available places; and we can only mention the scorpions and cockroaches that hid in the chinks and crevices of the fallen pines and club-mosses. All these would be interesting enough if time allowed, and interesting too would be the centipeds and land-snails that Dawson found in hollow Sigillarian stumps of the coal-measures of Nova Scotia. All would tend to enforce the lesson that the world in the Carboniferous age was controlled and operated very much as at present. Trees germinated and grew to perfection and died, and the hollow stumps became the refuge of myriads of creeping things, that found safety from hungry enemies only in complete concealment.

It is to the animals of higher rank that we must give attention. Let us remember that the Carboniferous age comes just after that which witnessed the introduction of fishes—the earliest as well as the lowest of animals having brains, and heads, and spinal columns. It lies, therefore, very near the focus toward which all the genealogical lines of our present vertebrates converge, and hence every structural feature in the higher Carboniferous animals becomes invested with a peculiar interest. Of true fishes there were none—they are a much later product—but, of creatures that combined in the most unthought-of ways the characters of both fish and reptile, the seas seem to have

been full. Fishes of the gar-pike pattern (and yet not like that either, for they were of no one pattern in particular), with lungs far enough developed to enable them to carry on respiration in the air as well as in the water, were on the whole most abundant. In some particulars these creatures stood very low in the scale of fish-life, and yet in others they outranked any fishes with which we are familiar. The curious mixing of class characters produced results always interesting, though sometimes ludicrous. The incongruity of these combinations seems to culminate in that absurd creature, neither one thing nor the other, from the coal-fields of Bavaria, which had the head, gills, backbone, and body generally, of a fish mounted on the limbs of a reptile (Fig. 14). Then there were real reptiles in the forests and coal-marshes; at least there were animals that by way of courtesy we may call reptiles, for they breathed air only, they were provided with true reptilian limbs, and the body was incased in a complete outfit of the

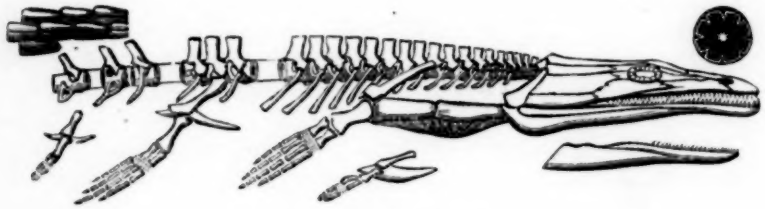

FIG. 14.—ARCHEGOSAURUS.

most approved reptilian armor. But in some respects they were not reptiles: the skeleton was imperfectly developed; the spinal column was such as belongs, of right, only to fishes; while the head and its articulation with the body, considered alone, would place them with the frog and salamander among the naked amphibians. These reptile-like creatures seem to have divided very early in their history, so as to follow two distinct lines of development: one group of small symmetrical forms, light of foot and swift of motion, frequented the higher portions of the land, and sought its food among the tribes of insects; the other, with strong limbs and jaws, with heavy body and aquatic habit, played the part of crocodiles. Now, these crocodiles were the lords of creation. All the while our coal was forming they stood at the head of created things. Had any human intelligence, with skill to read the geological record of all preceding time, been permitted to look in upon the Carboniferous world, he might well have believed that the end had come. He would have seen evidences of decay in many of the living tribes, and would have noticed that in all the past there were signs and promises and apparent preparations that seemed to point to these very tribes, and particularly to the crocodiles, as the complete realization and fulfillment of all creative designs. His human blindness to the

future would have prevented his seeing any promise beyond. But prophetic indications always become plainer after their fulfillment, and so we, by the aid of all subsequent life-history, are able to read in the structure of the Carboniferous reptiles the promise of better things. As the age draws on to its close, certain characters become more and more pronounced in some of the old, half-formed crocodiles, while a totally different set of peculiarities come to the front in others. Taking the whole group together, we find a very wide range of affinities indicated. One of these points by unmistakable signs to the dinosaurs—great, biped, bird-like reptiles that became conspicuous in the age following the coal. From these the passage is direct to the reptilian birds of the same age, so like dinosaurs in many particulars that they can hardly be distinguished. Then follows, after delay and successive changes of form reaching over geologic periods, the real bird type of our woods and fields, marvelous in its perfect adaptations and marvelous in its perfect symmetry and beauty.

But some of those old reptiles are fraught with suggestions of still higher meaning. In some of the groups recently brought to light from strata that mark the closing epochs of the Carboniferous age, the coming mammal is very plainly indicated. And so, if we only read aright, we may find in our piece of coal the suggestion and the promise of even the highest forms of life.

So it is that we have a very direct interest in that old coal age, an interest altogether independent of the coal itself, even though we know that modern industry and commerce and civilization, and the great centers of human population—the manufacturing and commercial cities, with all their wealth and magnificence—are directly dependent upon its marvelous stores of energy. The physicist will tell us how that energy, which drives our engines, warms and lights our rooms and makes it possible for us to sit here in comfort and never miss the light of the sun to-night, is simply so much force derived from the sunbeams of the Carboniferous age, invested for our benefit in the old ferns and club-mosses ; and yet our interest in the coal rises above all this. The roots of the present strike very deeply into the past, and nothing is risked in saying that, had the Carboniferous age, in its strangely constituted life-forms or in any other regard, been different in ever so small a degree, the present would not be just what it is. It is away back in the coal that we find, not only the promise of the grandly diversified system of vegetable life that lends so much of beauty and interest to the age in which we live ; but it was then, also, that manifest preparations were made for bringing upon the scene the various specialized groups of animals that are to-day a matter of personal concern to every one of us. It was in the coal, too, that we found the first real evident but rude shapings of the organic frame which we ourselves wear. Hugh Miller—an authority that may be safely introduced on this occasion—was accustomed to quote approv-

ingly from Dryden a stanza that to-day has more of meaning, perhaps, than either he or the poet ever perceived:

"From harmony, from heavenly harmony,
This universal frame began;
From harmony to harmony,
Through all the compass of the notes it ran,
The diapason closing full in man."

All investigation only adds grander significance to the grand utterance of Agassiz, that "man is the end toward which all the animal creation has tended since the first appearance of the first palæozoic fishes."

Is it not true that "an increasing purpose" does run through the ages by the processes of which, not only "the thoughts of men are widened," but enlarged encouragement is given to all their hopes and expectations of the future?

THE DEVELOPMENT OF POLITICAL INSTITUTIONS.

By HERBERT SPENCER.

V.—POLITICAL FORMS AND FORCES.

THE conceptions of biologists have been greatly advanced by the discovery that organisms which, when adult, appear to have scarcely anything in common, were, in their first stages, very similar; and that, indeed, all organisms start with a common structure. Recognition of this truth has revolutionized not only their ideas respecting the relations of organisms to one another, but also respecting the relations of the parts of each organism to one another.

If societies have evolved, and if that mutual dependence of their parts which social coöperation implies, and which constitutes them organized bodies, has been gradually reached, then the implication is that, however unlike their developed structures become, there is a rudimentary structure with which they all set out. And, if there can be recognized any such primitive unity, recognition of it will help us to interpret the ultimate diversity. We shall understand better how in each society the several components of the political agency have come to be what we now see them, and how those of one society are related to those of another.

Setting out with an unorganized horde, including both sexes and all ages, let us ask what must happen when some question, as that of migration or defense against enemies, has to be decided. The assembled individuals will fall, more or less clearly, into two divisions. The elder, the stronger, and those whose sagacity and courage have

been proved by experience, will form the smaller part, who carry on the discussion, while the larger part, formed of the young, the weak, and the undistinguished, will be listeners, who usually go no further than to express from time to time assent or dissent. A further inference may safely be drawn. In the cluster of leading men there is sure to be some one whose weight is greater than that of any other—some aged hunter, some distinguished warrior, some cunning medicine-man, who will have more than his individual share in forming the resolution finally acted upon. That is to say, the entire assemblage will resolve itself into three parts. To use a biological metaphor, there will, out of the general mass, be differentiated a nucleus and a nucleolus.

These first traces of political structure, which we infer *a priori* must spontaneously arise, we find have arisen among the rudest peoples; repetition having so strengthened them as to produce a settled order. When, among the aborigines of Victoria, a tribe plans revenge on another tribe supposed to have killed one of its members, "a council is called of all the old men of the tribe. . . . The women form an outer circle round the men. . . . The chief [simply 'a native of influence'] opens the council." And what we here see happening in an assemblage having no greater differences than those based on strength, age, and capacity, happens when, later, these natural distinctions have gained definiteness. In illustration may be named the account which Schoolcraft gives of a conference at which the Chippewas, Ottawas, and Pottawattamies, met certain United States commissioners, Schoolcraft being himself present. After the address of the head commissioner had been delivered, the speaking on behalf of the Indians was carried on by the principal chiefs; the lead being taken by "a man venerable for his age and standing." Though Schoolcraft does not describe the assemblage of undistinguished people, yet that they were present is shown by a passage in one of the native speeches: "Behold! see my brethren, both young and old—the warriors and chiefs—the women and children of my nation." And that the political order observed on this occasion was the usual order, is implied by its recurrence even in parts of America where chiefs have become marked off by ascribed nobility; as instance the account quoted by Bancroft of one of the Central American tribes, who "have frequent reunions in their council-house at night. The hall is then lighted up by a large fire, and the people sit with uncovered heads, listening respectfully to the observations and decisions of the *ahuales*—men over forty years of age, who have occupied public positions, or distinguished themselves in some way." Among peoples unlike in type and remote in locality, we find, modified in detail but similar in general character, this primitive governmental form. Of the Hill tribes of India may be instanced the Khonds, of whom we read that "assemblies of the whole tribe, or of any of its subdivisions, are convened, to determine

questions of general importance. The members of every society, however, have a right to be present at *all* its councils, and to give their voices on the questions mooted, although the patriarchs alone take a part in their public *discussion*. . . . The federal patriarchs, in like manner, consult with the heads of tribes, and assemble when necessary the entire population of the federal group."

In New Zealand the government was conducted in accordance with public opinion expressed in general assemblies; and the chiefs "could not declare peace or war, or do anything affecting the whole people, without the sanction of the majority of the clan." Of the Tahitians, Ellis tells us that the king had a few chiefs as advisers, but that no affair of national importance could be undertaken without consulting the land-holders or second rank, and also that public assemblies were held. Similarly of the Malagasy: "The greatest national council in Madagascar is an assembly of the people of the capital, and the heads of the provinces, towns, villages, etc." The king usually presides in person.

Though in these last cases we see considerable changes in the relative powers of the three components, so that the inner few have gained in authority at the expense of the outer many, yet all three are still present; and they continue to be present when we pass to sundry historic peoples. Even of the Phœnicians, Movers notes that "in the time of Alexander a war was decided upon by the Tyrians without the consent of the absent king, the senate acting together with the popular assembly." Then there is the familiar case of the Homeric Greeks, whose Agora, presided over by the king, was "an assembly for talk, communication and discussion to a certain extent by the chiefs, in presence of the people as listeners and sympathizers," who were seated around; and that the people were not always passive is shown by the story of Thersites, who, ill-used though he was by Odysseus and derided by the crowd for interfering, had first made his harangue. Again, the king, the senate, and the freemen, in primitive Rome, stood in relations which had manifestly grown out of those existing in the original assembly; for, though the three did not simultaneously coöperate, yet on important occasions the king communicated his proposals to the assembled burgesses, who expressed their approval or disapproval, and the clan-chiefs, forming the senate, though they did not debate in public, had yet such joint power that they could, on occasion, negative the decision of king and burgesses. Concerning the primitive Germans, Tacitus, as translated by Mr. Freeman, writes: "On smaller matters the chiefs debate, on greater matters all men; but so that those things whose final decision rests with the whole people are first handled by the chiefs. . . . The multitude sits armed in such order as it thinks good; silence is proclaimed by the priests, who have also the right of enforcing it. Presently the king or chief, according to the age of each, according to his birth,

according to his glory in war or his eloquence, is listened to, speaking rather by the influence of persuasion than by the power of commanding. If their opinions give offense, they are thrust aside with a shout; if they are approved, the hearers clash their spears."

Similarly among the Scandinavians, as shown us in Iceland, where, besides the general Al-thing annually held, which it was "disreputable for a freeman not to attend," and at which "people of all classes in fact pitched their tents," there were local assemblies called Var-things "attended by all the freemen of the district, with a crowd of retainers . . . both for the discussion of public affairs and the administration of justice. . . . Within the circle [formed for administering justice] sat the judges, the people standing on the outside." In the account given by Mr. Freeman of the yearly meetings in the Swiss cantons of Uri and Appenzell, we may trace this primitive political form as still existing; for though the presence of the people at large is the fact principally pointed out, yet there is named, in the case of Uri, the body of magistrates or chosen chiefs who form the second element, as well as the head magistrate who is the first element. And that in ancient England there was a kindred constitution of the Witenagemót, is indirectly proved; as witness the following passage from Freeman's "Growth of the English Constitution": "No ancient record gives us any clear or formal account of the constitution of that body. It is commonly spoken of in a vague way as a gathering of the wise, the noble, the great men. But, alongside of passages like these, we find other passages which speak of it in a way which implies a far more popular constitution. King Eadward is said to be chosen king by 'all folk.' Earl Godwine 'makes his speech before the king and all the people of the land.'" And the implication, as Mr. Freeman points out, is that the share taken by the people in the proceedings was that of expressing by shouts their approval or disapproval.

This form of ruling agency is thus shown to be the fundamental form, by its presence at the outset of social life and by its continuance under various conditions. Not among peoples of superior types only, such as Aryans and some Semites, do we find it, but also among sundry Malayo-Polynesians, among the red men of North America, the Dravidian tribes of the Indian hills, the aborigines of Australia. In fact, as already implied, governmental organization could not possibly begin in any other way. On the one hand, no controlling force at first exists save that of the aggregate will as manifested in the assembled horde. On the other hand, leading parts in determining this aggregate will are inevitably taken by the few whose superiority is recognized. And of these predominant men some one is sure to be most predominant. That which we have to note as specially significant, is not that a free form of government is the primitive form; though this is an implication which may be dwelt upon. Nor are we chiefly concerned with the fact that at the very beginning there

shows itself that separation of the superior few from the inferior many, which becomes marked in later stages; though this, too, is a fact which may be singled out and emphasized. Nor is attention to be mainly directed to the early appearance of a controlling head, having power greater than that of any other; though the evidence given may be cited to prove this. But here we have to note, particularly, the truth that at the very outset may be discerned the vague outlines of a triune political structure.

Of course, the ratios among the powers of these three components are in no two cases quite the same; and, as implied in sundry of the above examples, they everywhere undergo more or less change—change determined here by the emotional natures of the men composing the group, there by the physical circumstances as favoring or hindering independence, now by the activities as warlike or peaceful, and now by the exceptional characters of particular individuals.

Unusual sagacity, skill, or strength, habitually regarded by primitive men as supernatural, may give to some member of the tribe an influence which, transmitted to a successor supposed to inherit his supernatural character, may generate a chiefly authority subordinating both that of the other leading men and that of the mass. Or a division of labor, such that while some of the tribe remain exclusively warriors the rest are in a measure otherwise occupied, may give to the two superior components of the political agency an ability to override the third. Or the members of the third, keeping up habits which make coercion of them difficult or impossible, may maintain a general predominance over the other two. And then the relations of these three governing elements to the entire community may, and ordinarily do, undergo change by the formation of a passive class, excluded from their deliberations—a class at first composed of the women and afterward containing also the slaves or other dependents.

War, successfully carried on, not only establishes the passive or non-political class, but also, implying as it does subordination, changes more or less decidedly the relative powers of these three parts of the political agency. As, other things equal, groups in which there is little or no subordination are subjugated by groups in which subordination is greater, there is a tendency to the survival and spread of groups in which the controlling power of the dominant few becomes relatively great. In like manner, since success in war largely depends on that promptitude and consistency of action which singleness of will gives, there must, where warfare is chronic, be a tendency for members of the ruling group to become more and more obedient to its head: disappearance in the struggle for existence, among tribes otherwise equal, being ordinarily a consequence of inadequate obedience. And then it is also to be noted that the overrunnings of societies one by another, repeated and re-repeated as they often are, have the effect

of obscuring and even obliterating the traces of the original political form.

While, however, recognizing the fact that during political evolution these three primitive components alter their proportions in various ways and degrees, to the extent that some of them become mere rudiments or wholly disappear, it will greatly alter our conception of political forms if we remember that they are all derived from this primitive form—that a despotism, an oligarchy, or a democracy, is to be regarded as a type of government in which one of the original components has greatly developed at the expense of the other two, and that the various mixed types are to be arranged according to the degrees in which one or other of the original components has the greater influence.

Is there any fundamental unity of political forces accompanying this fundamental unity of political forms? While losing sight of the common origin of political structures, have we not also become inadequately conscious of the common source of their powers? How prone we are to forget the ultimate, while thinking of the proximate, it may be worth while pausing a moment to observe.

One, who in a storm watches the breaking-up of a wreck or the tearing down of a sea-wall, is impressed by the immense energy of the waves. Of course, when it is pointed out that in the absence of wind no such results can be produced, he recognizes the truth that the sea is in itself powerless, and that the power enabling it to destroy vessels and piers is given by the currents of air which roughen its surface. If he stops short here, however, he fails to identify the force which works these striking changes. Intrinsically, the air is just as passive as the water is. There would be no winds were it not for the varying effects of the sun's heat on different parts of the earth's surface. Even when he has traced back thus far the energy which undermines cliffs and makes shingle, he has not reached its source; for in the absence of that continuous concentration of the solar mass, caused by the mutual gravitation of its parts, there would be no solar radiations.

The tendency here illustrated, which all have in some degree and most in a great degree, to associate power with the visible agency exercising it, rather than with its inconspicuous source, has, as above implied, a vitiating influence on conceptions at large, and among others on political ones. Though the habit, general in past times, of regarding the powers of governments as inherent, has been, by the growth of popular institutions, a good deal qualified; yet, even now, there is no clear apprehension of the fact that governments are not themselves powerful, but are the instrumentalities of a power. This power existed before governments arose; governments were themselves produced by it; and it ever continues to be that which, disguised more or less completely, works through them. Let us go back to the beginning.

The Greenlanders are entirely without political control; having nothing which represents it more nearly than the deference paid to the opinion of some old man, skilled in seal-catching and the signs of the weather. But a Greenlander who is aggrieved by another has his remedy in what is called a singing combat. He composes a satirical poem, and challenges his antagonist to a satirical duel in face of the tribe: "He who has the last word wins the trial." And then Crantz adds: "Nothing so effectually restrains a Greenlander from vice as the dread of public disgrace." Here we see operating, in its original unqualified way, that governing influence of public sentiment which precedes more special governing influences. The dread of social reprobation is in some cases enforced by the dread of banishment. Among the otherwise unsubordinated Australians, they "punish each other for such offenses as theft, sometimes by expulsion from the camp." Of one of the Columbian tribes we read that "the Salish can hardly be said to have any regular form of government"; and then, further, we read that "criminals are sometimes punished by banishment from their tribe." Certain aborigines of the Indian hills, widely unlike these Columbians in type and in their modes of life, show us a similar relation between undeveloped political restraint and the restraint of aggregate feeling. Among the Bodo and Dhimáls, whose village heads are simply respected elders with no coercive power, those who offend against customs "are admonished, fined, or excommunicated, according to the degree of the offense." But the controlling influence of public sentiment, in groups which have little or no political organization, is best shown in the force with which it acts on those who are bound to avenge murders. Concerning the Australian aborigines, Sir George Grey writes: "The holiest duty a native is called on to perform is that of avenging the death of his nearest relation, for it is his peculiar duty to do so; until he has fulfilled this task, he is constantly taunted by the old women; his wives, if he is married, would soon quit him; if he is unmarried, not a single young woman would speak to him; his mother would constantly cry, and lament that she should ever have given birth to so degenerate a son; his father would treat him with contempt, and reproaches would constantly be sounded in his ear."

We have next to note that, for a long time after political control has made its appearance, it remains conspicuously subordinate to this control of general feeling; both because, while there is no developed political organization, the head-man has little ability to enforce his will, and because such ability as he has, if unduly exercised, causes desertion. From all parts of the world may be cited illustrations. In America, among the Snake Indians, "each individual is his own master, and the only control to which his conduct is subjected is the advice of a chief supported by his influence over the opinions of the rest of the tribe." Of a Chinook chief we are told that "his ability

to render service to his neighbors, and the popularity which follows it, is at once the foundation and the measure of his authority." If a Dakota "wishes to do mischief, the only way a chief can influence him is to give him something, or pay him to desist from his evil intentions. The chief has no authority to act for the tribe, and dare not do it." And among the Creeks, more advanced in political organization though they are, the authority of the elected chiefs "continues during good behavior. The disapproval of the body of the people is an effective bar to the exercise of their powers and functions." Turning to Asia, we read that the *bais* or chiefs of the Kirghiz "have little power over them for good or evil. In consideration of their age and blood, some deference to their opinions is shown, but nothing more." The Ostiaks "pay respect, in the fullest sense of the word, to their chief, if wise and valiant, but this homage is voluntary, and founded on personal regard." And of the Naga chiefs Butler says, "Their orders are obeyed so far only as they accord with the wishes and convenience of the community." So too is it in parts of Africa; as instance the Koranna Hottentots: "A chief or captain presides over each clan or *kraal*, being usually the person of greatest property; but his authority is extremely limited, and only obeyed so far as it meets the general approbation." And even among the more politically organized Caffres, there is a kindred restraint. The king "makes laws and executes them according to his sole will. Yet there is a power to balance his in the people: he governs only so long as they choose to obey." They leave him if he governs ill.

In its primitive form, then, political power is the feeling of the community, acting through an agency which it has either informally or formally established. Doubtless, from the beginning, the power of the chief is in part personal: his greater strength, courage, or cunning, enables him in some degree to enforce his individual will. But, as the evidence shows, his individual will is but a small factor; and the authority he wields is proportionate to the degree in which he expresses the wills of the rest.

While this public feeling, which first acts by itself and then partly through an agent, is to some extent the feeling spontaneously formed by those concerned, it is to a much larger extent the opinion imposed on them or prescribed for them. In the first place, the emotional nature prompting the general mode of conduct is derived from ancestors, being a product of all past activities; and, in the second place, the special motives which, directly or indirectly, determine the courses pursued, are induced during early life by seniors, and enlisted on behalf of beliefs and usages which the tribe inherits. The governing sentiment is, in short, mainly the accumulated and organized sentiment of the past.

It needs but to remember the mutilation to which, at a prescribed

age, each member of a tribe is subject—the knocking out of teeth, the gashing of the flesh, the tattooing, the submission to torture—it needs but to remember that from these imperative customs there is no escape, to see that the directive force which exists before political agency arises, and which afterward makes the political agency its organ, is the gradually formed opinion of countless preceding generations; or rather, not the opinion, which, strictly speaking, is an intellectual product wholly impotent, but the emotion associated with the opinion. This we everywhere find to be at the outset the chief controlling power.

The notion of the Tupis, that, "if they departed from the customs of their forefathers, they should be destroyed," may be named as a definite manifestation of the force with which this transmitted opinion acts. In one of the rudest tribes of the Indian hills, the Juángs, less clothed even than Adam and Eve are said to have been, the women long adhered to their bunches of leaves in the belief that change was wrong. Of the Koranna Hottentots we read that, "when ancient usages are not in the way, every man seems to act as is right in his own eyes." Though the Damara chiefs "have the power of governing arbitrarily, yet they venerate the traditions and customs of their ancestors." Smith says, "Laws the Araucanians can scarcely be said to have, though there are many ancient usages which they hold sacred and strictly observe." According to Brooke, among the Dyaks custom simply seems to have become the law, and breaking of the custom leads to a fine. In the minds of some clans of the Malagasy, "innovation and injury are . . . inseparable, and the idea of improvement altogether inadmissible."

This control by inherited usages is not simply as strong in groups of men who are politically unorganized, or but little organized, as it is in advanced tribes and nations, but it is stronger. As Sir John Lubbock remarks: "No savage is free. All over the world his daily life is regulated by a complicated and apparently most inconvenient set of customs (as forcible as laws), of quaint prohibitions and privileges." Though one of these rude societies appears to be structureless, yet its ideas and usages form a kind of invisible framework for it, serving rigorously to restrain certain classes of its actions. And this invisible framework has been slowly and unconsciously shaped, during daily activities impelled by prevailing feelings and guided by prevailing thoughts, through generations stretching back into the far past.

In brief, then, before any definite agency for social control is developed, there exists a control arising partly from the public opinion of the living and more largely from the public opinion of the dead.

But now let us note definitely a truth implied in some of the illustrations above given—the truth that, when a political agency has been evolved, its power, largely dependent on present public opinion, is

otherwise almost wholly dependent on past public opinion. The ruler, in part the organ of the wills of those around, is in a still greater degree the organ of the wills of those who have passed away; and his own will, much restrained by the first, is still more restrained by the last.

For his function as regulator is mainly that of enforcing the inherited rules of conduct which embody ancestral sentiments and ideas. Everywhere we are shown this. Among the Arafuras, such decisions as are given by their elders are "according to the customs of their forefathers, which are held in the highest regard." So is it with the Kirghiz: "The judgments of the *bais*, or esteemed elders, are based on the known and universally recognized customs." And in Sumatra "they are governed in their various disputes by a set of long-established customs (*adat*), handed down to them from their ancestors. . . . The chiefs, in pronouncing their decisions, are not heard to say, 'So the law directs,' but 'Such is the custom.'"

As fast as orally-preserved custom passes into written law, the political head becomes still more clearly an agent through whom the feelings of the dead control the actions of the living. That the power he exercises is mainly a power which acts through him, we see clearly on noting how little ability he has to resist it if he wishes to do so. His individual will is practically inoperative save where the overt or tacit injunctions of departed generations leave him free. Thus, in Madagascar, "in cases where there is no law, custom, or precedent, the word of the sovereign is sufficient." Among the East Africans, "the only limit to the despot's power is the *ada*, or precedent." Of the Javans, Raffles writes, "The only restraint upon the will of the head of the government is the custom of the country, and the regard which he has for his character among his subjects." In Sumatra the people "do not acknowledge a right in the chiefs to constitute what laws they think proper, or to repeal or alter their ancient usages, of which they are extremely tenacious and jealous." And how imperative is this conformity to the beliefs and sentiments of progenitors is shown by the fatal results apt to occur from disregarding them. "'The King of Ashantee, although represented as a despotic monarch, . . . is not in all respects beyond control.' He is under 'an obligation to observe the national customs, which have been handed down to the people from remote antiquity; and a practical disregard of this obligation, in the attempt to change some of the customs of their forefathers, cost Osai Quamina his throne.'" Which instance reminds us how commonly, as now among the Hottentots, as in the past among the ancient Mexicans, and as throughout the histories of civilized peoples, rulers have engaged, on succeeding to power, not to change the established order.

Doubtless the proposition that the political head, simple or compound, is in the main but an agency through which works the force

of public feeling, present and past, seems at variance with the many facts showing how great may be the power of a ruling man himself. Saying nothing of a tyrant's ability to take lives for nominal reasons or none at all, to make groundless confiscations, to transfer subjects bodily from one place to another, to exact contributions of money and labor without stint, we are apparently shown by his ability to begin and carry on wars which sacrifice his subjects wholesale, that his single will may override the will of the nation. In what way, then, must the original statement be qualified?

While holding that, in unorganized groups of men, the feeling manifested as public opinion controls political conduct, just as it controls the conduct distinguished as ceremonial and religious; and, while holding that governing agencies, during their early stages, are at once the products of aggregate feeling, derive their powers from it, and are restrained by it, we must admit that these primitive relations become complicated when, by war, small groups are compounded and recompounded into great ones. Where the society is largely composed of subjugated people held down by superior force, the normal relation above described no longer exists. We must not expect to find, in a rule coercively established by an invader, the same traits as in a rule that has grown up from within. Societies formed by conquest may be, and frequently are, composed of two societies, which are in large measure, if not entirely, alien; whence it results that there is no longer anything like such united feeling as can embody itself in a political force derived from the whole community. Under such conditions the political head either derives his power exclusively from the feeling of the dominant part of the community, or else, setting the diverse masses of feeling originated in the upper and lower societies one against the other, is enabled so to make his individual will the chief factor.

After making which qualifications, however, it may still be contended that, ordinarily, nearly all the force exercised by the governing agency originates from the feelings, if not of the whole community, yet of the part which is able to manifest its feelings. Though the opinion of the subjugated and unarmed lower society becomes of little account as a political factor, yet the opinion of the dominant and armed part continues to be the main cause of political action. What we are told of the Congo people, that "the king who reigns as a despot over the people is often disturbed in the exercise of his power, by the princes his vassals"—what we are told of the despotically-governed Dahomans, that "the ministers, war-captains, and feticheers may be, and often are, individually punished by the king: collectively they are too strong for him, and without their cordial coöperation he would soon cease to reign"—is what we recognize as having been true, and as being still true, in various better-known societies, where the power of the supreme head is nominally absolute. From the time when the Roman emperors were chosen by the soldiers and slain when they did

not please them, to the present time, when, as we are told of Russia, the desire of the army often determines the will of the Czar, there have been many illustrations of the truth that an autocrat is politically strong or weak according as many or few of the influential classes give him their support; and that even the sentiments of those who are politically prostrate greatly affect the political action: instance the influence of Turkish fanaticism over the decisions of the Sultan.

A number of facts must be remembered if we are rightly to estimate the power of the aggregate will in comparison with the power of the autocrat's will. There is the fact that the autocrat is obliged to respect and maintain the great mass of institutions and laws produced by past sentiments and ideas, which have acquired a religious sanction; so that, as in ancient Egypt, dynasties of despots live and die and leave the social order essentially unchanged. There is the fact that a serious change of the social order, at variance with general feeling, is likely afterward to be reversed, as when, in Egypt, Amenhotep IV, spite of a rebellion, succeeded in establishing a new religion, which was abolished in a succeeding reign; and there is the allied fact that laws much at variance with the general will prove abortive, as, for instance, the sumptuary laws made by mediæval kings, which, continually reënacted, continually failed. There is the fact that, supreme as he may be, and divine as the nature ascribed to him, the all-powerful king is yet shackled by usages which often make his daily life a slavery; the opinions of the living oblige him to fulfill the dictates of the dead. There is the fact that if he does not conform, or if he otherwise produces by his acts much adverse feeling, his servants, civil and military, refuse to act, or turn against him; and in extreme cases there comes an example of "despotism tempered by assassination." And there is the further fact that habitually, in societies where an offending autocrat is from time to time removed, another autocrat is set up; the implication being that the average sentiment is of a kind which not only tolerates but desires autocracy. That, which is by some called loyalty and by others servility, both creates the absolute ruler and gives him the power he exercises.

But the cardinal truth, difficult adequately to appreciate, is that, while the forms and laws of each society are the consolidated products of the emotions and ideas of those who have lived throughout the past, they are made operative by the subordination of existing emotions and ideas to them. We are familiar with the thought of "the dead hand" as controlling the doings of the living in the uses made of property; but the effect of "the dead hand," in ordering life at large through the established political system, is immeasurably greater. That which, from hour to hour, in every country, governed despotically or otherwise, produces the obedience making political action possible, is the accumulated and organized sentiment felt toward inherited institutions, made sacred by tradition. Hence it is undeniable that, taken in its

widest acceptation, the feeling of the community is the sole source of political power; in those communities, at least, which are not under foreign domination. It was so at the outset of social life, and it still continues substantially so.

It has come to be a maxim of science that in the causes still at work are to be identified the causes which, similarly at work during past times, have produced the state of things now existing. Acceptance of this maxim and pursuit of the inquiries suggested by it lead to verifications of the foregoing conclusions.

For day after day, every public meeting illustrates afresh this same differentiation characterizing the primitive political agency, and illustrates afresh the actions of its respective parts. There is habitually the great body of the less distinguished, forming the audience, whose share in the proceedings consists in expressing approval or disapproval, and saying ay or no to the resolutions proposed. There is the smaller part, occupying the platform—the men whose wealth, position, or capacity gives them influence—the local chiefs by whom the discussions are carried on. And there is the chosen head, commonly the man of greatest mark to be obtained, who exercises a recognized power over speakers and audience—the temporary king. Even an informally summoned assemblage soon resolves itself into these divisions more or less distinctly; and when the assemblage becomes a permanent body, as of the men composing a commercial company, or a philanthropic society, or a club, definiteness is quickly given to the three divisions —president or chairman, board or committee, proprietors or members. To which add that, though at first, like the meeting of the primitive horde or the modern public meeting, one of these permanent associations, voluntarily formed, exhibits a distribution of powers such that the select few and their head are subordinate to the mass; yet, as circumstances determine, the proportions of the respective powers usually change more or less decidedly. Where the members of the mass are not only much interested in the transactions, but are so placed that they can easily coöperate, they hold in check the select few and their head; but, where wide distribution, as of railway shareholders, hinders joint action, the select few become, in large measure, an oligarchy, and out of the oligarchy there not unfrequently grows an autocrat: the constitution becomes a despotism tempered by revolution.

In saying that from hour to hour proofs occur that the force possessed by a political agency is derived from aggregate feeling, partly embodied in the consolidated system which has come down from the past, and partly excited by immediate circumstances, I do not refer only to the proofs that among ourselves governmental actions are habitually thus determined, and that the actions of all minor bodies, temporarily or permanently incorporated, are thus determined. I refer, rather, to the illustrations of the irresistible control exercised by

average sentiment and opinion over conduct at large. Such facts as that, while public opinion is in favor of dueling, law fails to prevent it, and that sacred injunctions, backed by threats of damnation, are powerless to check the most iniquitous aggressions when the prevailing interests and passions prompt them, alone suffice to show that legal codes and religious creeds, with the agencies enforcing them, are impotent in face of an adverse sentiment. On remembering the eagerness for public applause and the dread of public disgrace which stimulate and restrain men, we can not question that the diffused manifestations of feeling habitually dictate their careers when their immediate necessities have been satisfied. It requires only to contemplate the social code which regulates life down even to the color of an evening necktie, and to note how those who dare not break this code have no hesitation in smuggling, to see that an unwritten law enforced by opinion is more peremptory than a written law not so enforced. And still more on observing that men disregard the just claims of creditors, who for goods given can not get the money, while they are anxious to discharge so-called debts of honor to those who have rendered neither goods nor services, we are shown that the control of prevailing sentiment, unenforced by law and religion, may be more potent than law and religion together when they are backed by sentiment less strongly manifested. Looking at the total activities of men, we are obliged to admit that they are still, as they were at the outset of social life, guided by the aggregate feeling, past and present; and that the political agency, itself a gradually-developed product of such feeling, continues still to be in the main the vehicle for a specialized portion of it, regulating actions of certain kinds.

Partly, of course, I am obliged here to set forth this general truth as an essential element of political theory. My excuse for insisting at some length on what appears to be a trite conclusion must be, that, however far nominally recognized, it is actually recognized to a very small extent. Even in our own country, where non-political agencies spontaneously produced and worked are many and large, and still more in most other countries less characterized by them, there is no due consciousness of the truth that the combined impulses which work through political agencies can, in the absence of such agencies, produce others through which to work. Politicians reason as though state-instrumentalities have intrinsic power, which they have not, and as though the feeling which creates them has not intrinsic power, which it has. Evidently their actions must be greatly affected by reversal of these ideas.

LINGERING BARBARISM.

TRANSLATED FROM THE GERMAN OF CARL VOGT BY A. R. MACDONOUGH.

THE striking feature of the present age is that outcropping of barbarism which has found in the persecution of the Jews an object for the full exercise of its passionate violence. It is our inheritance of centuries, hard to conquer, enduring as adamantine substance in those races that worked themselves out later than the rest into an existence worthy of man. Spite of all contradiction, I hold fast to this view, because it is true in its inmost core.

Just as an organism evolves, out of two mutually hostile tendencies, inheritance of character derived from ancestry, and acquirement of new advantages in the struggle for life through adjustment to its environment, so the special nature of a people builds itself up out of the inheritance bequeathed by its forefathers and the conquests it has won for itself in its contest for being. In a people's life, as in the individual's life, there are times when the one or the other of these striving forces steps into the foreground and thrusts the other back. Development does not advance with even flow, but by fits and starts—oftenest it is like that style of march in which two leaps are made backward after taking three forward.

We do leap—but it is backward, away into the middle ages, which we fancied we had got rid of.

The sign and token of our time contrasted with the middle ages is knowledge in contrast to belief; the exact method of research opposed to the sway of usurped authority; the free movement of forces all over the globe, as against limitation within narrow bounds and spaces; the peaceful, harmonious working of the nations toward high humane ends, as against their hostile rivalry to the end of subjection and ravage; the recognition of common human rights, as against the special claims of isolated castes and ranks. Whatever domain of political life we regard, we note everywhere the same tendency toward that reactionary groping after our inheritance from the middle ages.

Nor is this strange. One who clears his eyes from that whirlwind dust of glory flung abroad by warlike violence, and pictures pure fact to himself, sees that all its substantial results are due only to the systematic development and perfecting of material strength and power. He must logically come to the conclusion that the plant which has been so carefully nurtured and trained to the most vigorous productiveness can not wither down to its very root after this energetic effort. Victory always brings intoxication, and in its paroxysm those spirits are unchained which a sober and quiet life had fettered in the bonds of discretion. We insist on enjoying to the full the inheritance till now only partly spent.

Is it a matter for surprise, then, that Jewish persecution has found a foothold in the universities, among boys at their studies; that this German youth hurrahs for Treitschke, that Slavonic sprout, with his exclusive German utterances; or that their trainers in classics need to be reminded of good morals by paying them in the same coin they use to enlighten the babes and sucklings committed to their care?

Why should these boy-pupils, these buff-jerkined and jack-booted swaggerers, ingrained and inwrought in their very baby natures with the notion of distinction in ranks, not fall upon the "old-clo' peddler fellows," and all the more savagely because these dare to aim at becoming their rivals? How can one expect them to be just to descendants of an alien race, when it has been preached and crammed into them, from their breech-clout days, that the world's weal depends on their race alone; that their seed alone is called to lordship; and that all other nations in their rottenness are intended for nothing else but for service as their subjects and self-sacrifice to their mastery?

The root of the matter lies very much deeper. The world of antiquity, on which the education of our youth has been nourished since the middle ages, and is fed now, was founded on the institution of slavery; its whole existence would be as inconceivable apart from slavery as would be the aboriginal German world without woman's servile labor for her lazy lord and husband. The ancient German Tacitus drew was a hunter and fighter, stretched at odd times on his bear-skin, guzzling and gambling, while his Thusneldas and serfs did all the work for him, tilling the ground and sweating for his food. That was the German civilization which our students chant in their songs; and its traces are the tattoo-scars across their faces, of which they are so proud, though these are mere proofs of clumsiness, not signs of dangers met.

All the cultivation of the middle ages rested on so-called classical studies, which are bound up in the closest relations with barbarous and violent use of power. The Spanish mock stateliness of mediæval scholasticism is indivisible from the savagery of mediæval university life, and we have accepted it in these modern days along with the rest of our inheritance, and find it cherished and protected in our universities by the powers that be.

Our age strives and struggles for the recognition of the exact sciences which have thoroughly penetrated our life, as opposed to those systems of so called humanist education handed down to us from the middle ages. Unresting, unfaltering, exact science presses forward with its methods and results. It feeds and clothes us, multiplies our means of intercourse, controls our whole political and domestic economy, masters our thought and our feeling, and daily wins us new fruits of good in the struggle for existence. It knows no distinctions of peoples, castes, and nations; no qualification of territory or geographical restriction. There is no such thing as German steam-power,

or Semitic electricity, or Roman magnetism; it bids any and every people welcome that will promote science and lend it help.

When we remember that the natural sciences began only about a century ago to strive for a place in the state; that before that date they had been nothing more than the private affair of exceptional minds; that for the first half of our century even they played absolutely no part in public education, but only ran a tolerated subcourse with it in the universities, and were utterly unnoticed both in the lower schools and in special seminaries; that in my younger days a man might be regarded as cultivated without having the faintest notion of any natural science whatever; and that it was made a reproach to men like Goethe that they took any interest in the sciences, and showed an active concern about them—when we think of all this, and compare with it the circumstances of our day, and the tendencies of our times, we understand at once why those authorities who would step backward into bygone ages prefer so-called classical education and favor all the influences that have clung to it since mediæval days—why they would restore to the word that authority which is claimed to-day by the fact, and why those who are still paddling about in that cultivation, handed down to us from the middle ages, seize on every straw they fancy able to keep them above water. An instinct tells these half-taught noodles that the ground is slipping away from them; that a day is rapidly drawing near when those branches of knowledge, which they assert as of universal need for every man who claims to be cultivated, shall be worthless except as specialities; when only one here and there will trouble himself about whether some crowned cowherd marched with his mates on a plundering slave-hunt, as in Homer's times; and when the knowledge of Nature and her laws must come to the front as always indispensable to a liberal education. Just as that man, a century or so ago, was looked on as wholly neglected and uneducated who had not toiled at his school-desk over the scanning of Latin verses, so will people no long time hence be surprised at the careless lack of training in that man who has not mastered the mechanism of the telegraph or the laws of heat long before he takes his way to the university.

"My good man," wrote a Hessian landgrave at the beginning of the last century to his postmaster, who had cudgeled a royal messenger—"my good man, we have heard with the highest displeasure the steps you have presumed on in your inborn coarseness and clownishness." I don't know whether the Landgrave laid great stress on the word "inborn," but he certainly used it with the feeling that the case was one of inherited peculiarity. Now, in that day classical education held sole and undisputed rule; could it have pushed back heredity and stifled it by nobler growths?

Most surely not; and what classical training could not avail to do in centuries when it held sole sway, it is still more powerless to effect

now that a rival has grown up beside it which it never through all time can prevail against.

While writing this, a pamphlet is sent me by a friend, entitled "Secession—Berlin, Julius Springer, 1881," in which the anonymous but certainly very intelligent author questions our political and financial conditions from his point of view. While this pamphlet is highly remarkable, as well for its contents as for its way of expressing them, it is perhaps yet more remarkable for that which it either hints or leaves unsaid—I mean, to speak plainly, for its indulgence toward that easy-going confidence with which some of the eminent minds of the past ten years have allowed themselves to believe that the whole nature of mankind is radically changed, because it has walked for a while with a varnished cane instead of a knotty club. I find in it an agreement with my doctrine partly gratifying and partly saddening, since I can hardly understand how an author of so much insight should not long ago have felt the scales drop from his eyes. "Wherever our glance falls," he says, "nothing strikes us but ideas, laws, institutions, that existed a century ago, and yet have been set aside for ten years past or more, by the course of culture and increasing insight. Reaction toward restrictions on our trade with foreigners followed by restrictions on domestic trade; next, fetters on personal liberty and freedom of action; then, backward steps to the stern penal codes of past ages, and to the proscriptive and coercive laws of a patriarchal world. The whole contrivance, piece by piece, is borrowed and brought out from the rusty arsenal of the good old times. Whatever is now devised is dug up from the deep and ever-deeper dust of centuries."

It is even so. Yet it may, perhaps, be said that, with a little less classical and philosophical training, and a little more education in natural science, it would probably earlier have become evident that, even without wishing or intending it, we were taking an active part in this disinterment from the dust of centuries. At all events, it is well that this conviction is now forcing its way: it is only to be hoped that it may gain clearer reality and wider range in those who have won it.

These things, however, press with light weight in the scales of the future, how lamentable soever they may be in the present. Whether a reactionary law the more or the less be made, whether the secessionists thrive or perish, it is of course a pitiable sign of the times that the student body here roar with applause at their hero gabbler Treitschke, there pledge themselves to the Jewish persecution, and raise dueling squabbles about it—a sign hardly compensated for by the indignation with which the cities kick Chaplain Stöcker's nauseous double-faced hypocrisy out of doors. But this does not touch the root of the matter, which lies in the training of our youth in increasing waste-paper scribblings and reactionary barbarism. Not much improvement can be hoped for in the present generation; we may check and repress,

if we choose, the manifestations of their indwelling brutality, but can not hinder its secret permanence, amazing as such impulses seem to close observers. But all who are seriously devoted to progress may keep this truth fixed in view, that all elevation of classical studies at the expense of other branches of knowledge is a step backward into barbarism, and all furtherance of the exact sciences in the teaching of youth is a step forward toward civilization.

And, in this connection, I find great satisfaction in drawing attention to the address delivered at the opening of the Mason Science College, at Birmingham, by Huxley, the distinguished English scientist, and published in the number of "Nature" for October 7, 1880.

It seems that there arose in the mind of Sir Josiah Mason, an Englishman, apparently a money-getter of the purest type, the idea, certainly a most extraordinary one, of spending in his lifetime thousands of pounds, not in buying Krupp guns, but in establishing at Birmingham an amply endowed college, in which young persons might acquire "sound, extensive, and practical scientific knowledge." The founder of this institute leaves its managers all possible freedom as to the means for attaining this object, only binding teachers and pupils alike for all coming time in three particulars: Party politics of whatever nature are excluded; theology is shown the door once for all; and, in conclusion, it is expressly prescribed that the college shall make no provision for mere literary instruction and education.

There was something that did not occur to the mind of this Englishman, enriched by trade and industry, who felt that every step in his path of life was almost a stumble, by reason of his defective knowledge of the exact sciences. "It is not impossible," says Huxley, "that we shall hear this express exclusion of 'literary instruction and education' from a college which nevertheless professes to give a high and efficient education sharply criticised. Certainly the time was that the Levites of culture would have sounded their trumpets against its walls as against an educational Jericho."

The time has come, indeed, and the storm of indignation that arose, among the Levites of classical old England, is still echoing in the newspapers—a storm bursting not over the college alone, but specially over Huxley, so eminent in science, who dared in the course of his address to vindicate this idea.

"For those," he says, "who mean to make science their serious occupation, or who intend to follow the profession of medicine, or who have to enter early upon the business of life—for all these, in my opinion, classical education is a mistake; and it is for that reason that I am glad to see 'mere literary instruction and education' shut out from the curriculum of Sir Josiah Mason's college, seeing that its inclusion would probably lead to the introduction of the ordinary smattering of Latin and Greek. Nevertheless, I am the last person to question the importance of genuine literary education, or to suppose

that intellectual culture can be complete without it. An exclusively scientific training will bring about a mental twist as surely as an exclusive literary training. The value of the cargo does not compensate for the ship's being out of trim ; and I should be very sorry to think that this scientific college would turn out none but lop-sided men. There is no need, however, that such a catastrophe should happen. Instruction in English, French, and German is provided, and thus the three greatest literatures of the world are made accessible to the student."

Such is the way of it under the government of the classical Homer-student, Gladstone ! An Englishman, who is master of only three living languages and the exact sciences, is held to be as highly cultivated as a barrister who understands only English and some Latin and Greek, but has steered his way cleverly through Oxford or Cambridge !

But fancy for a moment that it should occur to the mind of some opulent Jew (such an idea surely would never strike a Christian German) to found such a "Mason's College" in Germany, on the plan of "no religious teaching, no politics, no Latin, and Greek." Shocking ! How happy we are to have a Stöcker, a Treitschke, and a Putkammer, who would not suffer a poison-plant like that to spring on German soil !

THE LEGAL POSITION OF MARRIED WOMEN.*

By Mrs. ANNA GARLIN SPENCER.

IT is my intention to indicate the historical scope and present bearings of my topic by a brief analysis of the following four conditions of social order involved in its consideration, viz. :

1. The law of social development underlying the various legal positions of married women, historically traced.

2. Classification of the principal types of marriage.

3. Summary of existing laws of married women in the United States.

4. Practical suggestions prompted by the study of these past and present facts.

Our first point (the social law controlling the varying position of married women) brings us at once to the fact that physical unions of men and women must have preceded all legal definitions of their relation to each other, or to their offspring. We begin to call these unions marriage, when the first headland of rude ceremonial selection appears above the sea of promiscuous passions. For a long while yet, no legal enactments fix the status of the wife ; but from the time of

* A paper read before the Association for the Advancement of Women, at Boston, October 14, 1880.

the most rudimentary marriage, on to the highest types of sexual nuion, those social laws which are the seed of governmental codes, and without knowledge of which we can not understand those codes, deal with woman in her wedded state. We find the position of the married woman, as defined by these social laws, written and unwritten—and, if unwritten, quite as likely to be stringently enforced—to furnish examples of every grade of condition, from the captured or purchased slave to the comparatively equal partner. Moreover, we find the woman sometimes in possession of the most personal freedom in the lowest general social development. What law governs these widely diverging conditions?

The student of sociology must be convinced that the *evolution of the family determines, in its different stages, the differing position of the married woman.*

For proof of this statement we have only to consider the following facts: Progress from barbarism to civilization is marked by ever-increasing political control, as opposed to accidental, shifting despotisms of powerful individuals on the one side, and to purposeless anarchy of the masses on the other. "Political control rests primarily on distinct relationships of blood." For the structural cohesion of the family, established by this definite blood-relationship, alone makes possible the structural cohesion of many families in the organism we call society. The unity of the family, therefore, being the fundamental condition of the unity of society, it is secured beyond peradventure by successive changes which tend more and more to establish certainty of descent, of preservation, and of care of offspring. Probably every form of relation between man and woman, from promiscuity to pure monogamy, has been in existence at every stage of human development. But the *prevailing type* of sexual union has differed at each of these differing stages. How do we know which are the higher and which are the lower of these types? By the application of the simple test-question, which the more perfectly secures that organization of the family which is the primary necessity of the organization of the state?

In the building up of the state, the primitive need is sufficient power and permanency of control to make law supreme over the individual will. And where the personal wishes or rights, even of men, come in conflict with this initial step toward social order, those personal wishes and rights are ruthlessly sacrificed; not because individual liberty is ignored in the process of development, but rather because individual liberty can only be permanently secured by making it second to social order in sequence of evolution. On exactly the same principle, the building up of the family, which precedes the establishment of political order, must begin in the strong foundation-wall of family unity, even although to that unity must be sacrificed the individual rights of every member of the family except its acknowledged head. Hence we

discover the law which underlies the varieties and changes in the condition of married women to be a law which concerns itself first, not with the rights of any individual *inside* the family, but with the development and defense of the family itself. For this development and defense of the family the following conditions must necessarily be secured :

a. Certainty of parentage of offspring on both male and female side, that inheritance may be secured.

b. Protection of the family from external encroachments of war, conquest, etc.

c. Nourishment of offspring, and such protection of the mother as will secure that end.

d. Repression of sexual passion to certain recognized limits.

e. Preservation of the family against the disruptive tendencies of internal strife.

Bearing these general principles in mind, we turn to the next division of our subject, viz. :

THE CLASSIFICATION OF THE PRINCIPAL TYPES OF MARRIAGE.—If our previous positions are correct, we must rank marriage types, from lowest to highest, by their growing ability to fulfill these conditions, tabulated above, of the development and defense of the family order :

We find the first primitive marriage to be a simple announcement of intention to live together by a man and woman, ratified by some such rude ceremony as that of the "Navajos, who sit down on opposite sides of a basket made to hold water and filled with some kind of food, and partake of it. . . . This proceeding makes them husband and wife." This type of union offers perfect freedom of choice to both parties to the contract, and, being broken at pleasure, is repeated as many times and dissolved as often as caprice indicates. Hence it offers but slight protection to the offspring, and the society in which it is found the prevailing type of sexual union is among the lowest in grade of development.

The next step up in marriage conditions is that called polyandry, or the union of several husbands to one wife. It is not to be inferred from this definition that polyandry at first, or generally, restrains the sexual indulgence of men to the fractional marital rights indicated. Far from it. Polyandry simply lays the corner-stone of the family foundation-wall by making a local home—i. e., a place where children can be generally known to belong. Let us see how this is done. Nature makes certain the parentage of the child on the mother's side, as she does not on the father's. Hence the primitive necessity in building the family is to put the mother in a definite place, and cluster her children round her, whether you can know the paternity of those children or not. Descent of name and inheritance

are possible, then, on one side the line. Fatherhood may pass through many stages, from a light flitting from one polyandric household to another, on to that form in which the several husbands of the female head of such households must be distinctly related to each other, but, through all the varieties of polyandry, the fixed stake of classification and localization of offspring defines the family outline. This type of marriage affords sometimes to women, "as in Thibetan polyandry, freedom and equality of companionship with men." It everywhere gives her such measure of power as her physical strength can command; and by interesting many men, although ever so slightly, in the welfare of some one household, it offers the beginning of protection to offspring, in supplies of food and defense in war.

The next step up in marriage types is to what we call polygyny, or the union of several wives with one husband. This establishes the descent of the child on both male and female sides of the marriage union; but *it destroys every vestige of freedom and equality in the condition of the wife.* With polygyny begins the legal, recognized slavery of woman to man in the domestic relation. Remember, however, that nature is securing first the family order, and only after that is attained can look out for personal rights; and let us note, without prejudice, the advance of this type of marriage, in family structure, above polyandry. Descent, reckoned on the father's side, not only secures double ancestry, but, on account of the greater brute strength of men, is more likely to keep the inheritance intact. Again, although women enjoy a nominal freedom before this point, it is only that gained by personal qualities—it has no bulwark of law. Hence the average woman, physically weaker than man, is his prey. Polygyny places her person in the custody of her husband, and thus enlists for its defense, against lawless raids of masculine lust, the selfish instinct of preservation of one's own property. And this protection of woman is absolutely indispensable, under barbarous conditions, not only for the growth of chastity on her part, but for the nourishment of offspring. We have this great gain in the family order in this type, that the *father* is brought into the household, and placed beside the mother and children. But, in order to get him there, we have to bring in with him facilities for the indulgence of his passions *within* the home, equal, or nearly so, to those he has before enjoyed outside the home. Repression of sexual passion to certain recognized limits was one of the conditions of family order we noted above. Polygyny marks the point at which the *chastity* of the mother was made the limit on one side, and the indulgence of the father, *only inside the household*, the limit on the other. This was a great gain in the line of repression, even although it gave man absolute power over as many wives as he could secure.

The next step up in marriage development we may call *rudimentary monogamy.* The last essential of family unity we noted was

the preservation of the family against the disruptive tendencies of internal strife. Polygyny partially and externally secures this by placing the control of the family in the hands of a recognized head, and that head the member of the household indisputably the best able to hold his position against the other members. But the elements of discord and strife were left in the family, in the jealousies of the several wives, and in the conflicting claims of their children. When death removed the household despot, if not before, these elements of disintegration worked against the family structure. Rudimentary monogamy was the attempt to settle by law the relative positions of a man's several wives, placing one on a secure height above the others, to insure a certain descent of title, property, and power to her children. Roman law gives us the most perfect legal form of this transition stage toward pure monogamy. The Roman patrician was entitled by law to three wives, but he could only have *one of the highest kind.* This superior order of wife, whom the law protected against equal rivals, must be of the same high birth as the husband, could alone legitimatize his children to the extent of transmission of title and estate (save as he exercised his legal power of adoption); and the marriage ceremony, made binding by solemn religious rites, was annulled only by death. The second grade of wife could be of inferior birth, and was united to her noble husband merely by a civil service, which gave him full power over her, but which secured her legal protection and support, and could be annulled by divorce. The third grade of wifehood was one which gave perfect legal independence to the woman, and also removed from her all legal protection. Simple announcement of intention to assume such a relation was the only preliminary needed for this union; it could be dissolved by mutual consent. Rudimentary monogamy, you observe, raised the standard of a life-long union of one man with one woman, to beget, bear, and rear one set of offspring. And the Roman law, though recognizing other unions as legal, pushed them away as far as possible from this germinal seed of perfect family unity. Thus the seed grew, and we come rapidly on the to the last type of marriage, viz.:

Pure monogamy. This form of sexual union recognizes no other as legally admissible. Indulgence of passion there may be outside this narrow bond of one man to one woman, but it is unlawful, and its fruits have no legal place in the social order of the family. This is the type dominant in our civilization, and we have seen how slowly it has been built up, and for what high ends of government.

THE LEGAL POSITION OF MARRIED WOMEN TO-DAY IN THE UNITED STATES.—Our laws are all founded on and modifications of the "common law" of England, which was in turn, for the most part, a gift from old Roman jurists to our civilization. This common law exemplifies in every word the emphasis formerly placed on the authority of recognized rulers, in general government and in domestic

order. The common law "merged the married woman's whole legal being in that of her husband." She might be heir to untold wealth; marriage made her husband legal owner of it all, with unchecked power over it, as well as over her expenses. She might be a Minerva of wisdom, but her every action must be obedient to her husband, though he were little above the idiot. She might be mother of a score of children, but her husband could will them all away from her control, even the unborn babe he should never behold. In short, she might be or do anything; her husband still had full power over her body, her actions, her property, her earnings, and her children. But, on the other hand, he was responsible for her crimes, her debts, her support, her protection from violence, and the support and protection of her children. If he could legally "correct her with a stick no bigger than his thumb," and that not with "cruelty," he must also answer by his own payment, or imprisonment, for her misdeeds, as for a minor child's. Thus was the monogamic unity of the family secured by the strong domestic control of a father-head, just as the organic unity of society was secured by the strong political control of an unlimited monarchy. And no doubt both forms of despotism have been necessary in the appropriate stages of human development. But, at the time our republic was born, it had become apparent to the dullest, as it had long been to prophetic minds, that the hour had arrived when political control must concern itself not only with its first great task, viz., the development of social order, but must set itself at work also on its second great effort, viz., *the definition and defense of personal rights inside of this social order.* Not only this, but it became apparent that the domestic order also contained within itself necessities for like definition and defense of personal rights. The tendency thus inaugurated naturally took shape first, in its relation to married women, in an increase of secured independence of personal action, and of parental control, to women cruelly abused or divorced or deserted by their husbands. It began to be seen that the wives of *bad* or *incompetent* men should not be the domestic slaves of those men. It began to be seen that the children of bad or incompetent fathers should have the protection and support he failed to give them provided by the other parent, who to that end should be endowed with certain powers of ownership of property and person. And, as legislators had their attention drawn to these truths by concrete illustrations of abuses, by husbands and fathers, of the law which gave them absolute power over wife and children, they tried to alter the law in one and another particular. Hence we find the old "common law," in the different States of our Union, with its darker spots torn out and patched over with new readings to such a degree that, in many cases, the original fabric is hardly distinguishable. A brief summary of these tearings out and patchings over will enable us to see the drift of legal changes respecting the matter in hand.

The common law recognized no legal right as inhering in the mar-

ried woman, *except the one supreme right of holding her husband true to the monogamic type of marriage.* The legal position of married women to-day represents as many different views of woman's legal rights in marriage as there are States in our Union. But all those States recognize that she has some rights of independent action, not only when her husband is bad or imbecile, but when he is good or competent. The confusing varieties of legislation on this point make summarizing extremely difficult. No generally received principle respecting the just legal relation between husband and wife has controlled the sweeping changes which the legislation of the last thirty years records. These changes have been simply irregular, fitful, and detached attempts to make the domestic yoke of women easier, in places where it was found specially to hurt. We find, however, that there is some approach to uniformity in the changes of the statute laws of old States, and that the legal codes of the new States take counsel generally of the old constitutions which have departed most widely from the original common-law slavery of women in the domestic relation.

Let us see what rights of independent action are now insured, or partially so, to married women.

We have thirty-eight States in our Union. In twenty-eight of these a married woman has legal ownership and separate control of all property owned by her before, or descending to her after, marriage. In ten States her property owned before marriage is secured against any attempt of her husband to alienate it without her consent, but he has full control of incomes resulting from it; and in two of these States the husband receives property which, were she single, would descend to her. In twenty-one States a married woman's earnings are her separate property; in eight States her right to such earnings is legally restricted in various ways, as in Georgia, where a married woman can own absolutely as separate property her own and her children's earnings deposited in a savings-bank "if the same do not exceed two thousand dollars"; and in nine States a woman can hold absolutely in her own control all property coming to her from any source save by gift of her husband—as in Massachusetts, where a recent decision of the Court under this law was that a woman could not own her own wardrobe if her husband gave her the money to buy it! This decision, we may add, a legislative enactment has very recently attempted to overrule by ordaining that a woman *may own* her personal apparel in Massachusetts.

In twenty-one States a married woman is solely liable for her antenuptial debts; in five States her husband is liable for them to the extent of the property she brought to the common stock at marriage.

In sixteen States a married woman can make a will devising her separate property according to her wish; in twelve States she can so will her estate, provided she gives her husband as much as the law of

that State would give him if she died intestate; and in one State she can make a will only by her husband's written consent.

In nine States special enactments qualify a married woman to be executrix or administratrix; in others the right is secured under other forms of law.

In twenty-four States a married woman may sue and be sued separately from her husband; in other States provision is made for their union in various specified suits.

In fourteen States married women can cause their husbands' lives to be insured for their benefit, and retain the policy against all outside claims, within certain limits of amount. In twenty-two States there are homestead acts which secure a certain amount of property, the home and its belongings, to the widow or wife, against all creditors of the husband. In fifteen States a married woman may carry on and control a separate business without limitations; in ten States she can do so with some restrictions, which vary from a simple requirement that she shall file her intention to do so in court to the necessity of proving that her husband does not support her properly.

In three States special enactments provide for trusteeships to guard the wife's interests against the husband's claims; in other States similar results may be attained by marriage contracts, and special provisions of various sorts. In seven States a woman is solely responsible for her personal debts. In three States a married woman is responsible for her husband's debts, and in two others is so responsible unless taking certain legal precautions at marriage. In six States her separate property is liable for family debts, although in most instances she is so liable only in the second degree, all the husband's property being jeopardized first.

In seven States the division of property on the death of either husband or wife, whether there be any issue or not, is very nearly or quite equal; in most of the other States the widower has nearly all the rights in the wife's estate he had under the common law, and she has a life interest in his real, and absolutely only a fraction of his personal, property.

In ten States, husbands and wives can make contracts with each other.

In regard to the rights of guardianship, the father is generally held first natural guardian of the children, and the mother second.

In Iowa, which, on the whole, seems to lead all the other States in giving equal marital and parental rights to husband and wife, the two parents are equal guardians of the children, neither having the power to remove them from the home without the consent of the other, and on the death of either parent the other is sole guardian. Moreover, in this State the wife can not be compelled by the husband to leave the home, against her wishes, to follow him in any wanderings. In Iowa, also, the family expenses are chargeable equally to both parents, and

on divorce the support of the children is still a mutual burden, and custody of the children is decreed to either parent—on discretion of the Court.

We come now to our last division, viz., practical considerations arising from the study of these facts of history, and of present condition.

I have tried to give the more important laws as they stand upon the statute-books. They mark an enormous increase of personal power in the married woman's condition during the last thirty years. But probably her actual legal position is more restricted still than these statutes would indicate. The average man wishes to do justice, as fast as he can see it. So the legislator responds to petitions to change laws deemed offensive. But the lawyer, accustomed to be guided by precedent, and fearful that decisions under the law of his State may be overruled by an appeal to a higher court, is shy of taking full advantage of a new statute. Thus it comes about that a woman must not place full reliance upon the "acts and resolves" of the General Assembly of her State. She must find out what is the actual practice among lawyers and judges. For instance, in Massachusetts, the law declares that woman owns her own property, and may manage it free from all interference; yet so many troublesome conditions are to be complied with, and in important cases there are so many possible risks from technical barriers, that many women still find it to their advantage to empower some man-friend with a trustee's external rights, that she may really control her own, through him in his capacity of agent. For instance, again, in California, where the "common property" of husband and wife is wholly under his control, and although her estate is called "separate," and she is declared to be legally protected in its control, the profits of both her and his separate estate are called "common property," and he has full disposal of them, unless by special arrangement otherwise. These, and many other instances, prove that the legal powers conferred on married women are often so *executed* and *interpreted* as to fall far short of their apparent scope. The first thing, therefore, for every married woman to do is to find out the statutes of her own State respecting her position, and then learn the actual practical bearing of the laws in any point that touches her. It may be that some movement for national legislation on the legal position of married women will be found necessary. Certainly, it ought not to be possible for men and women to assume the solemn obligation of marriage in one State, under one set of legal conditions, and one or the other party to the contract throw off those obligations in another State, under another set of legal conditions. There should be some uniformity of law, as to marriage contract and its dissolution by divorce, in the different States. Another practical consideration is this: women must be prepared to assume personal responsibilities as

they attain personal rights. No State Legislature has said "Go to, let us make the married woman the legal equal of her husband," but legislation has pointed in that direction more and more during these last years, so pregnant of changes in her position. If the married woman is to be the legal equal of her husband, she will find she must accept the penalties as well as gains of independence. The laws already indicate this. For instance, as soon as women were allowed to hold as separate property what they owned before marriage, they were made solely liable for their own antenuptial debts. As soon as women were allowed to hold as separate property what they gained in any way after marriage, they were made liable for their own separate debts incurred after marriage. And as soon as they were allowed to carry on separate trades and business, they were made partially or equally liable with the husband for the support of the family. Not that legislation in these two directions has been simultaneous or universally united; but these two tendencies are to be noted. And the one is the legitimate corollary of the other. As fast as the wife is removed from wardship to her husband, she should be required to assume her personal obligations and release him from them. The practical question now before us is, How far are these twin tendencies to proceed? Judging from facts of existing law, and analogies of other social movements, we may arrive at the conclusion that, just as in political control the overmastering impulse of growth is in the direction of the *greatest possible freedom of the individual, consistent with social cohesion*, so in domestic control the irresistible movement is in the direction of the most perfect *legal equality of the married partners, consistent with family unity.*

These exact limits we can not yet master in superficial detail, either in political government or family life. But past experience shows us that the measure of personal independence which woman can gain inside the family structure will alone be hers permanently. All attempts to abrogate the legal marriage tie, or to make her sole owner of the children, in order to secure her independent sovereignty, have been abortive movements, leading to a reversion to less developed forms of sexual union, or even to that promiscuity which (like political anarchy of revolt) demands the despotic rule of the strongest to lay again the foundations of progress. The States of our Union which have carried their legislative changes farthest in the direction of legal independence of married women have not yet settled fully the questions involved. For instance, in States accepting the principle of equal ownership of personal estate and equal responsibility for personal debts, the question as to which parent should be solely or chiefly responsible for the support of the family is only half met. In Connecticut (by its recent sweeping revision, which places it among the most advanced in respect to our topic) the father is made responsible, alone, for family expenses. But, if a woman owns personal property, should

she be allowed to shirk all family obligations, while presumably having a very considerable influence in determining the scale of living? Still more, should she be allowed to assist her husband in cheating his creditors, by contracting family debts in his name, which he can repudiate by passing his property into her hands, or by merely swearing he is bankrupt?

And, on the other hand, where, as in Iowa, the two heads of the married firm are made equally responsible by law for family expenses, should there not be an accompanying provision making the married partners equal owners of all *current incomes?*

And, again, where the principle of equality of rank of husband and wife, father and mother, in the home is fully conceded, how can it be applied in the detail of the unity of name and residence demanded? Man, as the senior partner, now gives the name and determines the legal residence. Some women claim the right to retain their own single names, and demand a legal recognition of that right. Should that be yielded in any case, which parent would then claim superiority of child-ownership in giving a name to the children? These and other delicate questions of adjustment must be determined, not by *a priori* reasoning, but by an appeal to past and present experience, with these two principles in view, viz., the primary need of family unity as a condition of social order, and the secondary need of increasing measure of personal independence for women within that unity. And since our legislative changes have been, for the most part, attempts to limit the *power of abuse* of the domestic control vested in the man, rather than efforts to secure the freedom of women from that control by the husband, the result is an inconsistent medley of laws, which at one time recognize the married woman as an independent unit, and at another time as the mere ward of her husband. The great practical need for the parties most interested—thoughtful, intelligent women—is a clear ideal of the just legal relations of men and women. With that ideal in mind, the laws, and *especially the actual practice under those laws*, should be examined, and, where they come short, they may in time be amended by slow, pacific, but persistent methods of educational appeal.

A great help to this end is the work which contributed so much toward the changes in Connecticut laws, the work recently so ably done for Massachusetts by Messrs. Almy and Fuller, viz., the compilation by reliable lawyers of the present laws, with an indication of all inequalities, and the injustice resulting from them.

Meanwhile, as the band of ancient law, which made woman the domestic slave of man, protected her from a worse fate, and made possible the primitive home, so the inconsistencies of our present laws make that band flexible in adjustment, even by ignorant or unconscious workers, to the present and future needs of woman and the home. Protected by these ever-changing codes, the higher uses of

the family life will develop—the more internal unity of the married twain and the more perfect moral nourishment of their offspring will bring on a civilization which must write itself out in "sweeter manners, purer laws."

ROCK-WEATHERING, AS ILLUSTRATED IN CHURCHYARDS.*

By Professor ARCHIBALD GEIKIE, F. R. S.

COMPARATIVELY little has yet been done in the way of precise measurement of the rate at which the exposed surfaces of different kinds of rock are removed in the processes of weathering. A few years ago some experiments were instituted by Professor Pfaff, of Erlangen, to obtain more definite information on this subject. He exposed to ordinary atmospheric influences carefully measured and weighed pieces of Solenhofen limestone, syenite, granite (both rough and polished), and bone. At the end of three years he found that the loss from the limestone was equivalent to the removal of a uniform layer 0·04 millimetre in thickness from its general surface. The stone had become quite dull and earthy, while on parts of its surface fine cracks and incipient exfoliation had appeared.† The time during which the observations were continued is, however, too brief to allow any general deductions to be drawn from them as to the real average rate of disintegration. Professor Pfaff relates that during the period a severe hailstorm broke one of the plates of stone. An exceptionally powerful cause of this nature might make the loss during a short interval considerably greater than the true average of a longer period.

It occurred to me recently that data of at least a provisional value might be obtained from an examination of tombstones freely exposed to the air in graveyards in cases where their dates remained still legible or might be otherwise ascertained. I have accordingly paid attention to the older burial-grounds in Edinburgh, and have gathered together some facts which have, perhaps, sufficient interest and novelty to be communicated to the Society.

At the outset it is of course obvious that, in seeking for data bearing on the general question of rock-weathering, we must admit the kind and amount of such weathering, visible in a town, to be in some measure different from what is normal in nature. So far as the disintegration of rock-surfaces is effected by mineral acids, for example, there must be a good deal more of such chemical change where sulphuric acid is copiously evolved into the atmosphere from thousands of chimneys, than in the pure air of country districts. In these

* A paper read to the Royal Society of Edinburgh, on April 19, 1880.

† "Allgemeine Geologie als exacte Wissenschaft," p. 317.

respects we may regard the disintegration in towns as an exaggeration of the normal rate. Still, the difference between town and country may be less than might be supposed. Surfaces of stone are apt to get begrimed with dust and smoke, and the crust of organic and inorganic matter deposited upon them may in no small measure protect them from the greater chemical activity of the more acid town rain. In regard to the effect of daily or seasonal changes of temperature, on the other hand, any difference between town and country may not impossibly be on the side of the town. Owing, probably, to the influence of smoke in retarding radiation, thermometers placed in open spaces in town commonly mark an extreme nocturnal temperature not quite so low as those similarly placed in the suburbs, while they show a maximum day temperature not quite so high.

The illustrations of rock-weathering presented by city graveyards are necessarily limited to the few kinds of rock employed for monumental purposes. In this district the materials used are of three kinds: 1. Calcareous, including marbles and limestones; 2. Sandstones and flagstones; 3. Granites.

I. Calcareous.—With extremely rare exceptions, the calcareous tombstones in our graveyards are constructed of ordinary white saccharoid Italian marble. I have also observed a pink Italian shell-marble and a finely fossiliferous limestone containing fragments of shells, foraminifera, etc.

In a few cases the white marble has been employed by itself as a monolith in the shape of an obelisk, urn, or other device; but most commonly it occurs in slabs which have been tightly fixed in a framework of sandstone. These slabs, from less than one to fully two inches thick, are generally placed vertically; in one or two examples they have been inserted in large horizontal sandstone slabs or "through-stanes." The form into which it has been cut and the position in which it has been erected have had considerable influence on the weathering of the stone.

A specimen of the common white marble employed for monumental purposes was obtained from one of the marble works of the city, and examined microscopically. It presented the well-known granular character of true saccharoid marble, consisting of rounded granules of clear, transparent calcite, averaging about $\frac{1}{100}$ inch in diameter. Each granule has it own system of twin lamellations, and not unfrequently gives interference colors. The fundamental rhombohedral cleavage is everywhere well developed. Not a trace exists of any amorphous granular matrix or base holding the crystalline grains together. These seem molded into each other, but have evidently no extraordinary cohesion. A small fragment placed in dilute acid was entirely dissolved. There can be no doubt that this marble must be very nearly pure carbonate of lime.

The process of weathering in the case of this white marble pre-

sents three phases, sometimes to be observed on the same slab, viz., superficial solution, internal disintegration, and curvature with fracture.

1. *Superficial solution* is effected by the carbonic acid and partly by the sulphuric acid of town rain. When the marble is first erected it possesses a well-polished surface capable of affording a distinct reflection of objects placed in front of it. Exposure for not more than a year or two to our prevalent westerly rains suffices to remove this polish, and to give the surface a rough, granular character. The granules which have been cut across or bruised in the cutting and polishing process are first attacked, and removed in solution or drop out of the stone. An obelisk in Greyfriars Churchyard, erected in memory of a lady who died in 1864, has so rough and granular a surface that it might readily be taken for a sandstone. So loosely are the grains held together that a slight motion of the finger will rub them off. In the course of solution and removal, the internal structure of the marble begins to reveal itself. Its harder nests and veinings of calcite and other minerals project above the surrounding surface, and may be traced as prominent ribs and excrescences running across the faint or illegible inscriptions. On the other hand, some portions of the marble are more rapidly removed than others. Irregular channels, dependent partly on the direction given to trickling rain by the form of the monumental carving, but chiefly on original differences in the internal structure of the stone, are gradually hollowed out. In this way the former artificial surface of the marble disappears, and is changed into one that rather recalls the bare, bleached rocks of some mountain-side.

The rate at which this transformation takes place seems to depend primarily on the extent to which the marble is exposed to rain. Slabs which have been placed facing to the northeast, and with a sufficiently projecting architrave to keep off much of the rainfall, retain their inscriptions legible for a century or longer. But even in these cases the progress of internal disintegration is distinctly visible. Where the marble has been less screened from rain, the rapidity of waste has been sometimes very marked. A good illustration is supplied by the tablet of G—— G——, on the south side of Greyfriars Churchyard, who died in 1785.* This monument had become so far decayed as to require restoration in 1803. It is now, and has been for some years, for the most part utterly illegible. The marble has been dissolved away over the center of the slab to a depth of about a quarter of an inch. Yet this monument is by no means in an exposed situation. It faces eastward in a rather sheltered corner, where, however, the wind eddies in such a way as to throw the rain against the part of the stone which has been most corroded.

* For obvious reasons I withhold the names carved on the tombstones referred to in this communication.

In the majority of cases superficial solution has been retarded by the formation of a peculiar gray or begrimed crust, to be immediately described. The marble employed here for monumental slabs appears to be peculiarly liable to the development of this crust. Another kind of white marble, sometimes employed for sculptured ornaments on tombstones, dissolves without crust. It is snowy white, and more translucent than the ordinary marble. So far as the few weathered specimens I have seen enable me to judge, it appears to be either Carrara marble or one of the strongly saccharoid, somewhat translucent varieties employed instead of it. This stone, however, though it forms no crust, suffers marked superficial solution. But it escapes the internal disintegration which, so far as I have observed, is always an accompaniment of the crust. But the few examples of it I have met with hardly suffice for any comparison between the varieties.

2. *Internal Disintegration.*—Many of the marble monuments in our older churchyards are covered with a dirty crust, beneath which the stone is found on examination to be merely a loose, crumbling sand. This crust seems to form chiefly where superficial solution is feeble. It may be observed to crack into a polygonal network, the individual polygons occasionally curling up so as to reveal the yellowish-white crumbling material underneath. It also rises in blisters, which, when they break, expose the interior to rapid disintegration.

So long as this begrimed film lasts unbroken the smooth face of the marble slab remains with apparently little modification. The inscription may be perfectly legible; the moment the crust is broken up, however, the decay of the stone is rapid. For we then see that the cohesion of the individual crystalline granules of the marble has already been destroyed, and that the merest touch causes them to crumble into a loose sand.

It appears, therefore, that two changes take place in upright marble slabs freely exposed to rain in our burial-grounds—a superficial, more or less firm crust is formed, and the cohesion of the particles beneath is destroyed.

The crust varies in color from a dirty gray to a deep brown-black, and in thickness from that of writing-paper up to sometimes at least a millimetre. One of the most characteristic examples of it was obtained from an utterly decayed tomb (erected in the year 1792), on the east side of Canongate Churchyard. No one would suppose that the pieces of flat dark stone lying there on the sandstone plinth were once portions of white marble. Yet a mere touch suffices to break the black crust, and the stone at once crumbles to powder. Nevertheless, the two opposite faces of the original polished slab have been preserved, and I even found the sharply-chiseled socket-hole of one of the retaining nails. The specimen was carefully removed and soaked in a solution of gum, so as to preserve it from disintegration. On submitting the crust of the marble to microscopic investigation, I found it to consist

of particles of coal, grains of quartz-sand, angular pieces of broken glass, fragments of red brick or tile, and organic fibers. This miscellaneous collection of town dust was held together by some amorphous cement which was not dissolved by hydrochloric acid. At my request my friend Mr. B. N. Peach tested it with soda on charcoal, and at once obtained a strong sulphur reaction. There can be little doubt that it is mainly sulphate of lime. The crust which forms upon our marble tombstones is thus a product of the reaction of the sulphuric acid of the town rain upon the carbonate of lime. A pellicle of amorphous gypsum is deposited upon the marble and incloses the particles of dust which give the characteristic sooty aspect to the stone. This pellicle, of course, when once formed, is comparatively little affected by the chemical activity of rain-water. Hence the conservation of the even surface of the marble. It is liable, however, to be cracked by an internal expansion of the stone to which I shall immediately refer, and also to rise in small blisters, and, as I have said, its rupture leads at once to the rapid disintegration of the monument.

The cause of this disintegration is the next point for consideration. Chemical examination revealed the presence of a slight amount of sulphate in the heart of the crumbling marble; but the quantity appeared to me to be too small seriously to affect the cohesion of the stone. I submitted to microscopic examination a portion of a crumbling urn of white marble in Canongate Churchyard. The tomb bears a perfectly fresh date of "1792" cut in sandstone over the top; but the marble portions are crumbling into sand, though the structure faces the east, and is protected from vertical rain by arching mason-work. A small portion of the marble retaining its crust was boiled in Canada balsam, and was then sliced at right angles to its original polished surface. By this means a section of the crumbled marble was obtained which could be compared with one of the perfectly fresh stone. From the dark outer amorphous crust with the carbonaceous and other miscellaneous particles, fine rifts could be seen passing down between the separated calcite granules, which in many cases were quite isolated. The black crust descends into these rifts, and likewise passes along the cleavage-planes of the granules. Toward the outer surface of the stone, immediately beneath the crust, the fissures are chiefly filled with a yellowish, structureless substance, which gave a feeble glimmering reaction with polarized light, and inclosed minute amorphous aggregates like portions of the crust. It probably consists chiefly of sulphate of lime. But the most remarkable feature in the slide was the way in which the calcite granules had been corroded. Seen with reflected light, they resembled those surfaces of spar which have been placed in weak hydrochloric acid to lay bare inclosed crystals and zeolites. The solution had taken place partly along the outer surfaces, so as to produce the fine passages or rifts, and partly along the cleavage. Deep cavities, defined by intersecting cleavage-planes, appeared

to descend into the heart of some of the granules. In no case did I observe any white pellicle such as might indicate a redeposit of lime from the dissolved carbonate. Except for the veining of probable sulphate just referred to, the lime when once dissolved had apparently been wholly removed in solution. There was further to be observed a certain dirtiness, so to speak, which at the first glance distinguished the section of crumbled marble from the fresh stone. This was due partly to corrosion, but chiefly to the introduction of particles of soot and dust, which could be traced among the interstices and cleavage lamellæ of the crystalline granules, for some distance back from the crust.

It may be inferred, therefore, that the disintegration of the marble is mainly due to the action of carbonic acid in the permeating rain-water, whereby the component crystalline granules of the stone are partially dissolved and their mutual adhesion is destroyed. This process goes on in all exposures, and with every variety in the thickness of the outer crust. It is distinctly traceable in tombstones that have not been erected for more than twenty years. In those which have been standing for a century it is, save in exceptionally sheltered positions, so far advanced that a very slight pressure suffices to crumble the stone into powder. But with this internal disintegration we have to take into consideration the third phase of weathering to which I have alluded. In the upright marble slabs it is the union of the two kinds of decay which leads to so rapid an effacement of the monuments.

3. *Curvature and Fracture.*—This most remarkable phase of rock-weathering is only to be observed in the slabs of marble which have been firmly inserted into a solid framework of sandstone and placed in an erect or horizontal position. It consists in the bulging out of the marble, accompanied with a series of fractures. The change can not be explained as mere sagging by gravitation, for it usually appears as a swelling up of the center of the slab, which continues until the large, blister-like expansion is disrupted. Nor is it by any means exceptional; it occurs as a rule on all the older upright marble tablets, and is only found to be wanting in those cases where the marble has evidently not been fitted tightly into its sandstone frame. Wherever there has been little or no room for expansion, protuberance of the marble may be observed. Successive stages may be seen, from the first gentle uprise to an unsightly swelling of the whole stone. This change is accompanied by fracture of the marble. The rents in some cases proceed from the margin inward, more particularly from the upper and under edges of the stone, pointing unmistakably to an increase in volume as the cause of fracture. In other cases the rents appear in the central part of the swelling, where the tension from curvature has been greatest.

Some exceedingly interesting examples of this singular process of

weathering are to be seen in Greyfriars Churchyard. On the south wall, in the inclosure of a well-known county family, there is an oblong upright marble slab measuring 30¼ inches in height by 22⅜ inches in breadth, and three fourths of an inch in thickness, facing west. The last inscription on it bears the date 1838, at which time it was no doubt still smooth and upright. Since then, however, it has escaped from its fastenings on either side, though still held firmly at the top and bottom. It consequently projects from the wall like a well-filled sail. The axis of curvature is of course parallel to the upper and lower margins, and the amount of curvature from the original vertical line is fully two and a half inches, so that the hand and arm can be inserted between the curved marble and the perfectly vertical and undisturbed wall to which it was fixed. At the lower end of this slab a minor curvature, to the extent of one eighth of an inch, is observable coincident with the longer axes of the stone. In both cases the direction of the bending has been determined by the position of the inclosing solid frame of sandstone which resisted the internal expansion of the marble. Freed from its fastenings at either side, the stone has assumed a simple wave-like curve. But the tension has become so great that a series of rents has appeared along the crest of the fold. One of these has a breadth of one tenth of an inch at its opening.* Not only has the slab been ruptured, but its crust has likewise yielded to the strain, and has broken up into a network of cracks, and some of the isolated portions are beginning to curl up at the edges, exposing the crumbling, decayed marble below. I should add that such has been the expansive force of the marble that the part of the sandstone block in the upper part of the frame exposed to the direct pressure has begun to exfoliate, though elsewhere the stone is quite sound.

More advanced stages of curvature and fracture may be noticed on many other tombstones in the same burying-place. One of the most conspicuous of these has a peculiar interest from the fact that it occurs on the tablet erected to the memory of one of the most illustrious dead whose dust lies within the precincts of the Greyfriars—the great Joseph Black. He died in 1799. In the center of the sumptuous tomb raised over his grave is inserted a large upright slab of white marble, which, facing south, is protected from the weather partly by heavy overhanging masonry, and partly by a high stone wall immediately to the west. On this slab a Latin inscription records with pious reverence the genius and achievements of the discoverer of carbonic acid and latent heat, and adds that his friends wished to mark his resting-place by the marble while it should last. Less than eighty years, however, have sufficed to render the inscription already partly illegible. The stone, still firmly held all round its margin, has bulged out

* It is a further curious fact that the slab measures half an inch more in breadth across the center, where it has had room to expand, than at the top, where it has been tightly jammed between the sandstone slabs.

considerably in the center, and on the blister-like expansion has been rent by numerous cracks which run on the whole in the direction of the length of the stone.

A further stage of decay is exhibited by a remarkable tomb on the west wall of the Greyfriars Churchyard. The marble slab, bearing a now almost wholly effaced inscription, on which the date 1779 can be seen, is still held tightly within its inclosing frame of sandstone slabs, which are firmly built into the wall. But it has swollen out into a ghastly protuberance in the center, and is, moreover, seamed with rents which strike inward from the margins. In this and in some other examples the marble seems to have undergone most change on the top of the swelling, partly from the system of fine fissures by which it is broken up, and partly from more direct and effective access of rain. Eventually the cohesion of the stone at that part is destroyed, and the crumbling marble falls out, leaving a hole in the middle of the slab. When this takes place disintegration proceeds rapidly. Three years ago I sketched a tomb in this stage on the east wall of Canongate Churchyard. In a recent visit to the place I found that the whole of the marble had since fallen out.

The first cause that naturally suggests itself, in explanation of this remarkable change in the structure of a substance usually regarded as so inelastic, is the action of frost. White statuary marble is naturally porous. It is rendered still more so by that internal solution which I have described. The marble tombstones in our graveyards are, therefore, capable of imbibing a relatively large amount of moisture. When this interstitial water is frozen, its expansive force as it passes into the solid state must increase the isolation of the granules and augment the dimensions of a marble block. I am inclined to believe that this must be the principal cause of the change. Whatever may be the nature of the process, it is evidently one which acts from within the marble itself. Microscopic examination fails to discover any chemical transformation which would account for the expansion. Dr. Angus Smith has pointed out that in towns the mortar of walls may be observed to swell up and lose cohesion from a conversion of its lime into the condition of sulphate. I have already mentioned that sulphate does exist within the substance of the marble, but that its quantity so far as I have observed is too small to be taken into account in this question. The expansive power is exerted in such a way as not sensibly to affect the internal structure and composition of the stone, and this, I imagine, is most probably the work of frost.

The results of my observations among our burial-grounds show that, save in exceptionally sheltered situations, slabs of marble exposed to the weather in such a climate and atmosphere as those of Edinburgh are entirely destroyed in less than a century. When this destruction takes place by simple comparatively rapid superficial solution and removal of the stone, the rate of lowering of the surface amounts sometimes to

about a third of an inch (or roughly nine millimetres) in a century. Where it is effected by internal displacement, a curvature of two and a half inches with abundant rents, a partial effacement of the inscription and a reduction of the marble to a pulverulent condition may be produced in about forty years, and a total disruption and effacement of the stone within one hundred. It is evident that white marble is here utterly unsuited for out-of-door use, and that its employment for really fine works of art which are meant to stand in the open air in such a climate ought to be strenuously resisted. Of course, I am now referring not to the durability of marble generally, but to its behavior in a large town with a moist climate and plenty of coal-smoke.

II. Sandstones and Flagstones.—These, being the common building materials of the country, are of most frequent occurrence as monumental stones. When properly selected, they are remarkably durable. By far the best varieties are those which consist of a nearly pure fine silicious sand, with little or no iron or lime, and without trace of bedding structure. Some of our sandstones contain 98 per cent. of silica. A good illustration of their power of resisting the weather is supplied by Alexander Henderson's tomb in Greyfriars Churchyard. He died in 1646, and a few years afterward the present tombstone, in the form of a solid square block of freestone, was erected at his grave. It was ordered to be defaced in 1662 by command of the Scottish Parliament, but after 1688 it was repaired. Certain bullet-marks upon the stone are pointed out as those of the soldiery sent to execute the order. Be this as it may, the original chisel-marks on the polished surface of the stone are still perfectly distinct, and the incised lettering remains quite sharp. Two hundred years have effected hardly any change upon the stone, save that on the west and south sides, which are those most exposed to wind and rain, the surface is somewhat roughened, and an internal fine parallel jointing begins to show itself.

Three obvious causes of decay in arenaceous rocks may be traced among our monuments. In the first place, the presence of a soluble or easily removable matrix in which the sand-grains are imbedded. The most common kinds of matrix are clay, carbonates of lime and iron, and the anhydrous and hydrous peroxides of iron. The presence of the iron reveals itself by its yellow, brown, or red color. So rapid is disintegration from this cause, that the sharply-incised date of a monument erected in Greyfriars Church to an officer who died only in 1863 is no longer legible. At least one eighth of an inch of surface has here been removed from a portion of the slab in sixteen years, or at the rate of about three fourths of an inch in a century.

In the second place, where a sandstone is marked by distinct laminæ of stratification, it is nearly certain to split up along these lines under the action of the weather if the surface of the bedding planes is directly exposed. This is well known to builders, who are quite aware of the importance of "laying a stone on its bed." Examples may be observed

in our churchyards, where sandstones of this character have been used for pilasters and ornamental work, and where the stone set on its edge has peeled off in successive layers. In flagstones, which are merely thinly-bedded sandstones, this minuter lamination is fatal to durability. These stones, from the large size in which slabs of them can be obtained and from the ease with which they can be worked, form a tempting material for monumental inscriptions. The melancholy result of trusting to their permanence is strikingly shown by a tombstone at the end of the South Burying Ground in Greyfriars Churchyard. The date inscribed on it is 1841, and the lettering that remains is as sharp as if cut only recently. The stone weathers very little by surface disintegration. It is a laminated flagstone set on edge, and large portions have scaled off, leaving a rough, raw surface where the inscription once ran. In this instance a thickness of about one third of an inch has been removed in forty years.

In the third place, where a sandstone contains concretionary masses of different composition or texture from the main portion of the stone, these are apt to weather at a different rate. Sometimes they resist destruction better than the surrounding sandstone, so as to be left as prominent excrescences. More commonly they present less resistance, and are therefore hollowed out into irregular and often exceedingly fantastic shapes. Examples of this kind of weathering abound in our neighborhood. Perhaps the most curious to which a date can be assigned are to be found in the two sandstone pillars which until recently flanked the tomb of Principal Carstares in Greyfriars Churchyard. They were erected some time after the year 1715. Each of them is formed of a single block of stone about eight feet long. Exposure to the air for about one hundred and fifty years has allowed the original differences of texture or composition to make their influence apparent. Each is hollowed out for almost its entire length on the exposed side into a trough four to six inches deep and six to eight inches broad. As they lean against the wall beneath the new pillars which have supplanted them, they suggest some rude form of canoe rather than portions of a sepulchral monument.

Where concretions are of a pyritous kind, their decomposition gives rise to sulphuric acid, some of which combines with the iron and gives rise to dark stains upon the corroded surface of the stone. Some of the sandstones of this district, full of such impurities, ought never to be employed for architectural purposes. Every block of stone in which they occur should be unhesitatingly condemned. Want of attention to this obvious rule has led to the unsightly disfigurement of public buildings.

III. Granites.—In Professor Pfaff's experiments, to which I have already referred, he employed plates of syenite and granite, both rough and polished. He found that they had all lost slightly in weight at the end of a year. The annual rate of loss was estimated by him as equal

to 0·0076 millimetre from the unpolished and 0·0085 from the polished granite. That a polished surface of granite should weather more rapidly than a rough one is perhaps hardly what might have been expected. The same observer remarks that, though the polished surface of syenite was still bright at the end of not more than three years, it was less so than at first, and in particular that some figures indicating the date, which he had written on it with a diamond, had become entirely effaced. Granite has been employed for too short a time as a monumental stone in our cemeteries to afford any ready means of measuring even approximately its rate of weathering. Traces of decay in some of its feldspar-crystals may be detected, yet in no case that I have seen is the decay of a polished granite surface sensibly apparent after exposure for fifteen or twenty years. That the polish will disappear, and the surface will gradually roughen as the individual component crystals are more or less easily attacked by the weather, is of course sufficiently evident. Even the most durable granite will probably be far surpassed in permanence by the best of our silicious sandstones. But as yet the data do not exist for making any satisfactory comparison between them.—*Nature.*

THE STATE AS AN EDUCATOR.*

By H. H. WILSON.

OF all the institutions which we are proud to call American, none makes so great an expenditure as our system of public education, and none receives so little critical attention from those by whom it is supported. It is seldom referred to except for purposes of flattery. Of all the offspring of American liberty this is the pet, and, as usual, it is the spoiled child. And this will probably remain so as long as indiscriminate praise is more welcome than just criticism.

I purpose, in the few minutes allotted to me, to discover, if possible, the true sphere of the state in reference to the education of the young. I shall use the word *state* in its broadest sense—a community of persons living within a limited territory and bound together by political ties. If such a community has a right to exist, then it has a right to do anything that is necessary to maintain that existence—to appropriate private property and even to take life itself. But, while the power of the state is thus broad, its duty is proportionally narrow, namely, to protect the person and property of the subject from the violence and fraud of his fellows. While for this purpose no sacrifice is too great, yet to exact from the subject more than is necessary for this purpose is legalized spoliation; for, when you take of a man's property more

* Read before the State Teachers' Association at Seward, Nebraska, April 1, 1880.

than is necessary to protect his person and the remainder of his property, you violate those very rights for the protection of which alone governments are instituted among men. Then, before the state can be justified in undertaking any enterprise, it must be shown, first, that the thing to be done is necessary either for the maintenance of its own existence or for the protection of the persons and property of its subjects; and, second, it must also be shown that it can be done better by the state than by individual effort.

There is at present in America a strong tendency to enlarge this sphere of government. Indeed, it may be said that it is our national weakness to look to the Government for everything. Thousands seek to throw upon the state the responsibility for miseries brought on by their own injudicious actions. The fact is that, beyond the safety of person and property, government forms one of the least factors in that complex product called happiness. Our greatest danger is the danger of being governed too much. As a result of this tendency to increase the domain of government, we have technical and professional colleges established and maintained by the state. When tried by our first criterion, I apprehend that it would be difficult to show that it is necessary to educate physicians and lawyers at public expense in order to protect persons and property; and it may well be doubted whether the rapid increase in the membership of these professions, due in no small degree to these institutions, is a national blessing. "But," it is asked, "are not the physician, the advocate, the engineer, necessary to the convenience and happiness of the community?" Certainly, so are food, clothing and shelter; yet not even Bentham thought of providing these at public expense. Then what special claims can these institutions have upon the public? The same arguments that would justify the state in educating the lawyer and doctor would also justify it in endowing the grocer and clothier, for they, too, are necessary to the convenience and happiness of society.

Moreover, the state, by supporting these institutions of special education, inflicts a positive injury upon society in crowding these favored professions, by thus interfering with those laws of social equilibrium which alone should govern the choice of vocation. Whenever the state by special legislation renders one vocation more accessible than another, it injures society by turning into one channel the intellectual energy that rightfully belongs in another. If, then, our premise be correct, these expensive institutions of technical learning are beyond the true province of the state.

But if the state is not denied all right to teach, what instruction shall she give? I answer, those things that will enable the rising generation to perform intelligently their functions as citizens. Yet how many leave our state institutions learned in the literature of Greece and Rome, but ignorant of our own history; conversant with the ideal republic of Plato, but unacquainted with the writings of our own Hamilton;

charmed with the beauties of Homer and Virgil, but deficient in the elements of political economy; able to compute the distance of the sun, but incapable of explaining our system of national currency! Take, if you will, the curricula of the high schools, colleges, and universities of the land, and compute the percentage of studies found there that are calculated to make competent members of the commonwealth! And yet this is the boasted system of education upon which we are told the perpetuity of our government depends!

It now becomes necessary to apply to education our second test, namely: Can it be done more efficiently by the state than by individual effort? Many, no doubt, who are ready to accept the conclusions already reached on the subject of special education, will still be inclined to think that general instruction should be at the expense and under the control of the state. But, before we attempt to decide by what agency we can best attain a certain object, it is necessary that we should have a well-defined idea of that object. What, then, is the true object of education? It is, if I mistake not, to aid Nature in perfecting the individual. Its aim should be to promote, not to destroy, individuality. Its object is human development, but, in the language of Von Humboldt, it is human development in its richest diversity.

The great poet Goethe saw and the naturalist Von Baer formulated the truth that in all organic life development consists of a change from a state of homogeneity to a state of heterogeneity; that, as we ascend the scale of animal life, there is a gradual transition from the like to the unlike, from unity to diversity. The social organism is no exception to this general law, and so we find among savages a marked similarity in costume, food, habits of life and in opinions. But as we ascend the scale of civilization we find fewer universal habits and still fewer universal opinions. Indeed, it has been shown that those opinions which are universal usually date back to the childhood of the race, and hence are usually false. Then social as well as physical development is a change from the homogeneous to the heterogeneous. But all history shows that nations as well as individuals have not only a period of youth and of manhood, but also a period of decay and of death. What is the cause of this fatal event which nations like individuals have sought, but sought in vain, to evade? Where does this retrograde movement begin? Nations decline because the conditions of their development are reversed; and decay begins just at that point at which the tendency to heterogeneity is exchanged for the tendency to homogeneity—at that point at which the people cease to become more diversified and begin to become more and more alike. There is in the development of nations a unanimity of savagery, a diversity of progress, and again a unanimity of stagnation. In view of these facts it becomes the duty of the educator to give full scope to the individual, and to encourage rather than restrain the peculiarities of the young.

If these propositions be true, it is, then, by no means clear that the

state is the most efficient educator of youth. The vastness of the enterprise demands the most rigorous system. But the more rigorous the system the less room will there be for the development of individual differences. The tendency of such a system is to make the mind a mere receptacle which receives its daily portion of mental pabulum. Even if trained to think at all, they must of necessity be trained to think very much alike, which is but little better than no thought. In other words, as the system grows stronger the individual grows proportionally weaker.

China, whose philosophers first recognized the supremacy of force, and whose moralists gave us a code which, after twenty-five centuries have elapsed, is yet too exalted for practical life, was reduced to her present condition, not for want of talent, of which she had much, but by a most rigorous system of state education, which consisted, not of investigating new phenomena, but of conning by rote what their ancestors had taught them. But we need not go to the Orient to witness the effects of state education. Germany has a most unyielding system, whose fruits are already beginning to ripen. This gigantic system, the pride of the Old World and the wonder of the New, is fast reducing the German mind to a mere repository of facts and figures. It will be remembered that no one can enter a German university until he has spent nine years in the gymnasium, chiefly upon Latin and Greek. To show the influence of such a course of study, I can do no better than to quote the words of Lord Macaulay, who says : "Unfortunately, those grammatical and philological studies, without which it was impossible to understand the great works of Athenian and Roman genius, have a tendency to contract the views and deaden the sensibilities of those who follow them with extreme assiduity. A powerful mind which has been long employed in such studies may be compared to the gigantic spirit in the Arabian tale, who was persuaded to contract himself to small dimensions in order to enter within the enchanted vessel, and, when his prison had been closed upon him, found himself unable to escape from the narrow boundaries to the measure of which he had reduced himself."

France until recently had a most perfect system of state instruction. No private schools could be established without a license from the Minister of Education, and these might be closed at any moment by a simple order from that officer. Under this system France made rapid strides toward that condition in which China has so long remained. M. de Tocqueville, that clear-headed Frenchman to whom America owes so much, remarked that his countrymen of his day were much more alike than their ancestors even of the next previous generation.

There are reasons why the effects of state education will not so readily discover themselves in America. In the first place, our system is yet very imperfect. But the chief reason is our extensive foreign

immigration, whose heterogeneity tends to counteract the unifying influence of our education. This, however, can not always last, and we shall hope in vain if we hope to escape the effects of those influences which are shaping the destinies of other nations. True, we permit parents to educate their own children, but at the same time we tax them to support the education of all; and we shall find but few who are able and still fewer who are willing to pay others to educate their children and then do it themselves. So our system is virtually a prohibition upon all private schools.

Nor has America entirely escaped the dwarfing influence of such a system. A recent writer says that while the percentage of college graduates is rapidly increasing, strange as it may seem, the percentage of college-bred men in public positions is decreasing. This, however, does not show that we as Americans are slow to recognize ability, for in no other country is true merit so sure to be rewarded; but I believe it does show that our education has a tendency to unfit men for the practical affairs of life. The demand is not for cultured minds filled with facts tumbling over each other in the dark, but for minds trained to independent thought. The question is repeated more and more emphatically, not what do you know, but what can you do? Every vocation of life is crying itself hoarse for men—men with the intellectual audacity to think and the moral courage to do.

It is the tendency of state education to make all intellectually alike, by urging the slow and restraining the fast, by giving a surface polish to the dull and bedimming the brilliant. Its tendency is to crush genius and enthrone mediocrity. It is the great leveling influence of modern times. This procrustean system binds its tender victims upon its inexorable bedstead of iron, and if found too short it cruelly attempts to stretch them out, until not unfrequently the brittle thread of life itself is broken in the effort; and if, when placed upon it, they perchance extend beyond its limits, they are as remorselessly trimmed down to the required standard.

Fortunately for mankind, some of the great minds of the age escaped the influence of popular education. When at the age of fourteen Henry Thomas Buckle won his first prize, his parents asked him to name anything he chose as an additional reward, and, with his wonderful precocity, he asked to be removed from public school. His request was granted, and who that has read his "History of Civilization" can doubt the wisdom of his choice? Herbert Spencer, any one of whose numerous volumes would place him in the first rank, not only as a student of human nature but also as a philosopher and man of letters, was never at public school. John Stuart Mill, than whom England has never produced a greater, who united in one mind the wisdom of the ancients and the learning of the moderns, who was at once an Aristotle and a Bacon, who was not only a profound philosopher but also a practical man of affairs, was singularly exempt from the influ-

ence of public instruction. Should the glaciers once more descend from the north and sweep before them all that makes us a great people, leaving no vestige of civilization behind, would America be known to future generations and handed down in history as the land of the most expensive school system on the globe, or would it be known as the birthplace of our Franklins, our Greeleys, our Lincolns, whose school-days might be counted on the fingers?

I would not, however, be misunderstood. I do not wish to see the whole system of state instruction destroyed at one fell swoop. Revolutions, in educational as well as in political and religious systems, should be gradual, lest the destruction of an institution so interwoven with the various interests of men should prove too great a shock for the ever-frail structure of society. Even at best we shall be compelled to educate a portion of the community at public expense, so must we also feed and clothe them. This, however, is no reason why all the children of the land should be reduced to the same mental diet.

I believe that the only way in which we can hope to carry forward our civilization, or even keep it from retrograding, is jealously to guard the integrity of the individual, and to make the temple of the mind so sacred that neither law nor custom shall be able to enter and enslave. It is therefore high time to cry a halt in this rapid encroachment of the state upon the domain of the individual. It now becomes the imperative duty of every friend of America to strive to limit the state to its true function, and thus avert, if possible, those evils which have buried historic nations beneath their classic ruins. For the conclusion, however unpalatable it may be, is forced upon us, that the perfection of our system of state education implies the destruction of individuality, and that the destruction of individuality means social, political, intellectual stagnation, the last symptom of that fatal disease to which China long ago fell a victim, which is even now gnawing at the vitals of France and Germany, and of whose insidious approach America may well beware.

MORALS OF LUXURY.*

By ÉMILE DE LAVELEYE.

THE real question to be considered in discussing the ethics of luxury is, Is it useful? This question has a bearing on living issues, for it touches the foundation of the contentions which threaten civilized societies. It is well considered in the "History of Luxury"† of M. Baudrillart, who has brought to his work the result of twenty years of

* Translated and adapted from the "Revue des Deux Mondes" by W. H. Larrabee.

† "Histoire du Luxe, privé et public." Par M. H. Baudrillart, de l'Institut. 4 vol. Paris, 1878, 1880.

study in philosophy and political economy. He presents the subject in a moral and philosophical view, in the light of the history of luxury, and with the aid of the side-lights of the judgments which have been expressed upon it at different epochs, from which citations are made.

It is first necessary to understand the sense in which the word luxury is used. I designate as an object of luxury everything that does not answer to some primary need, and which, costing much money and consequently much labor, is within the reach of only a small number of persons. An extravagant consumption is one that destroys the product of many days of labor without bringing any rational satisfaction to the one who makes it, as when a ballroom queen spoils in the whirls of the dance a lace robe worth ten thousand francs, destroying in a moment the equivalent of fifty thousand hours of eye-taxing labor. What advantage does any one derive from the waste? It follows from our definition that an object may be a luxury at one time and cease to be so at another, when it can be procured without great expense. As Roscher says,* the motive here is wholly relative. Each people and each age considers that which it is in the habit of doing without as superfluous. The chronicle of Holinshed complains of the refinements of the English of his time (1577), who introduced chimneys instead of letting the smoke escape through the holes in the roof, and used dishes of earthenware or tin instead of the wooden vessels with which they had got along before. Another author of the same time, Slaney, "On Rural Expenditure," was indignant at the employment of oak instead of willow in building, saying: "Formerly the houses were of willow, and the men of oak; now it is the contrary." When calicoes and muslins were first brought from the Indies, only the rich could wear them; now working-people think lightly of them. The progress of art is thus constantly bringing more objects within the reach of the greatest number; but the definition remains that that is extravagant which is at the same time superfluous and dear.

From his analysis of the feelings which give rise to luxury, M. Baudrillart educes three which he considers natural and universal: vanity, sensuality, and the instinct for adornment. Vanity makes one desire to be distinguished and to surpass others in appearance; to pass before the crowd, that admires riches and power, as powerful and rich. When a woman pays ten thousand dollars for a necklace of fine pearls, she does not do it simply to possess something handsome and adorn herself, for false pearls would be more shapely and quite as lustrous, but because the costly necklace will be the emblem and sign of her opulence. People when they see it will say she is rich, and her lesser rivals will be jealous, adding a seasoning to her vanity. In the gratification of this feeling we seek satisfaction in a factitious existence in the opinions of other persons. It is a general sentiment, and has a

* "Die Grundlagen der Nationalökonomie," iv, 2.

remarkable power. When public opinion inclines toward virtue, it may become a stimulant for good, but will lead to luxury and corruption among a public adoring riches.

Vanity, and the love of dress that it engenders, which are very marked with the savage who tattooes before he clothes himself, become refined among civilized men and in the fashionable world, and are tempered and turned in a better direction as culture is developed and the rule of good sense becomes more influential. Formerly men, like women, wore bright goods, galoons, lace, jewels; but, since the beginning of this century, civilized nations have adopted the black coat of England; it has come to be regarded as in bad taste for a man to display jewels, and simplicity, carefulness, and extreme propriety are regarded as constituting the whole of masculine elegance. Women, however, continue to bore their ears to put rings in them, and seek to adorn themselves with trinkets of glass and metal. How may we cure this infirmity, inherited from primitive barbarism? John Stuart Mill has pointed out the way by suggesting that when woman is trained to occupy herself with affairs of the mind, she will, like modern man, cease to take pleasure in gewgaws. Christianity has already worked miracles in this direction among the Quakers and in convents: why may it not, in alliance with the culture of the reason and the sentiment of justice, do more?

The kind of luxury that has its roots in sensual seeking is harder to contend against than that which arises from vanity, because it compels us to deal with enjoyments which are real though wholly superficial. On this point M. Baudrillart remarks that as matter is finite by its nature, sensuality is limited in its capacities. Man, however, deludes himself into believing that this is not the case. It seems to him that no enjoyment procures for him the gratification it ought to give; so, when he has exhausted one, he craves another pleasure. The refinements become nicer, and new ones are demanded. Dearness heightens the enjoyment by adding to the charm of an object agreeable in itself the piquant relish of a difficulty overcome. We may give all real satisfaction to the senses without excessive expenditure. The extravagant cost is occasioned by the desire to shine, ostentatiousness, to which there are no limits. It was not in mere sensuality that Cleopatra swallowed a pearl, and Heliogabalus ate a dish of nightingales' tongues. Progress in the arts of production may bring us abundance of all that is useful; but, if the object is to distinguish ourselves from others, it is necessary to consume, at any price, what is dear and rare.

The third source of luxury is the instinct for adornment, which, as M. Baudrillart well says, must not be confounded with ostentatiousness, even when that finds its only expression in it, or with sensuality, even when it ministers to it. It is primitive with man, for the prehistorical cave-dwellers carved on pieces of bone the figures of the reindeer and beavers that lived in the land in their times. Cultivated and

refined, it has become the æsthetic sentiment, the love of the beautiful, which has created all the arts. Instead of condemning it, it is proper to encourage it and exalt it, for in public monuments it becomes an agent of civilization and a source of pure, disinterested enjoyments accessible to the whole people. Applied in private life to the decoration of houses, furniture, and articles of use, and in everything to the choice of beautiful forms, as was done in antiquity, it purifies the taste and becomes an instrument of progress. The love of the beautiful and the instinct for adornment are good in themselves, and do not necessarily urge to luxury, for it is not in the dearness of the material but in the harmony of the colors and the purity of the lines that they should be manifested. The difference between luxury and art is thus indicated by M. Baudrillart: "Art pursues the realization of the beautiful, or the reproduction of certain forms. Luxury has only one aim —to seem. The object of art is essentially disinterested; that of luxury is egotistical. In the eye of luxury, the beautiful itself, the object of the passionate pursuit of the true artist charmed with perfection, is only something that glitters. Luxury pays for art as it pays for matter, and buys great works just as it spends money for jewels and fine goods." These incentives to luxury are reënforced by the love of change, which is revealed principally in the caprices of fashion. Fashion is one of the plagues of the times, and produces evils of various kinds. First, according to the M. Baudrillart, it makes the mind frivolous by diverting it from the things that ought to occupy it. "Those who make a point of elegance are obliged to employ themselves considerably with their clothes, and to devote to them a degree of study which certainly can not elevate their minds or make them capable of great things." This is the moral evil. The economical evil is well described by M. J. B. Say: "Fashion has the privilege of throwing things away before they have lost their usefulness, frequently even before they have lost their freshness; it multiplies consumption and condemns what is still good, neat, and becoming to be good for nothing. Thus the rapid succession of fashions impoverishes a state both as to what it consumes and what it does not consume." To make a goods of silk, wool, or cotton, of a new pattern, the expense of designs, models, printing-rollers, etc., must be incurred. What is not sold during the year becomes a remnant which is disposed of at a discount. Certain styles are not to the taste of the public, and are left to be sold at half price. All of the advances and losses must be covered by the total of sales, or the ruined manufacturer will have to cease producing. The changes of fashion thus considerably augment the price of all the objects to which they apply. If the costume were not so changing, the current manufacture of the goods which it requires would be carried on at better advantage than that of the thousands of different styles that arise in the different seasons of every year.

M. Baudrillart takes a position between the rigorous school, which advocates the retrenchment of wants, and the lax school, which regards luxury as something agreeable to the person and necessary to the state, and as indispensable to the progress of civilization; and he distinguishes between a luxury that is virtuous, permissible, and even laudable, and one which is improper and immoral. I can not admit the distinction; and I believe that the rigorous school is right. The condemnations which have been pronounced against luxury by the sages and philosophers of antiquity, the fathers of the Church, and the orators of the pulpit, are justified by the conclusions of modern thought. These men were ignorant of political economy, but they were inspired by right instincts and sentiments.

We have said that luxury consists in the consumption, to satisfy a factitious want, of something that has cost much labor. While labor is necessary to secure the satisfaction of bare needs, and while so many men are living in almost absolute destitution, can it be legitimate to employ a great part of the forces of capital and workmen which are at our disposition in producing superfluities which we would often be better without? A thing may cost enormous sums and still be useless and even injurious. Thousands of workmen are employed in the preparation of diamonds; but if the only use of the diamonds is to stimulate the vanity of those who possess them and to excite envy in those who have none, it would be better if they were sent to the bottom of the ocean. If the same workmen were employed in making articles of comfort for those who are in need of them, would it not be a subject for congratulation? I do not advocate sumptuary laws, but I look with pleasure on countries like Norway and the Alpine cantons of Switzerland, where, although no one buys diamonds, all have the means to procure necessaries. The real point to be considered is, that every object of luxury costs a great deal of labor; could not this labor be made useful in a more rational manner? The truth will appear more clearly by regarding an isolated individual. Would any man devote three years to making for himself a jewel that will be of no service to him? The absurdity of the actual transaction is hidden by the appearance of an exchange and the fact that the wearer of the jewel commands it of another. If we regard humanity in the light of a man obliged to satisfy his wants by his labor, it will appear to be folly to employ a part of the time in cutting diamonds, and in return to be obliged to go barefooted another part of the time. The inhabitants of a state have the disposal of a certain number of hours in a day; if they employ half of them in making futilities, it is evident that half the population will want for necessaries.

While M. Baudrillart condemns what he considers improper luxury with sufficient energy, he assumes that the procuring of necessaries does not afford a sufficient incentive to effort, and that a certain degree of luxury, of a moderate and moral kind, is indispensable as a

stimulant to labor. I admit, with John Stuart Mill, that it may be well to give new wants to still savage people, so that their energy and ingenuity may be stimulated and they be lifted out of a condition of indolence by the exertion necessary to satisfy those wants; but the taste for consuming is not the one that needs to be stimulated among European peoples. The greater number of men, even in a country as rich as France, have not such homes, or furniture, or clothing, or food as hygiene requires, nor such as they all certainly would desire to have. Is not this want of necessaries sufficient to urge them to labor? It is the only incentive of those who labor with their hands; and it is only those who are at ease that seek for the superfluous. "But what," says M. Baudrillart, "will you do with those thousands of artists, those hundreds of thousands of workmen, who are working in metals, in cloths, ivory, woods, gems, with infinite taste?" The eminent economist himself answers the question a few pages further on, in replying to those who say that France "produces too much." "What does this fortunate France produce too much of? It is not of the things useful or agreeable in life when there are so many poor. Let some one point out what it is that is produced in superabundance. Is it wool, when so many are cold? Is it grain, when so many are in want of bread?" Let the men who are working at ivory and gems produce the wool and the grain which you say are lacking, and the question will be answered.

M. Baudrillart regards a small number of wants as a sign of inferiority, and supposes that the development of material wants corresponds with that of the moral faculties. This is true in the earlier stages of civilization, but ceases to be so in the later stages, when the development of wants is so little a sign of progress that they have been most multiplied and refined in times of laxity, corruption, and decadence. This is exemplified and proved in the case of the Roman Empire, where the impossible was pursued, and extravagance sought the height of enjoyment in the indulgence of perverted fancies.

Economists are accustomed to measure the degree of civilization of a country by its productive power. In a certain country the rich lay the world under contribution for the adornment of their mansions and the supply of their tables, while a million poor people may be living on public charity, a third of the population may be illiterate, another third may be without necessaries, and the prisons may have to be enlarged and martial law proclaimed. No matter; that country is called the most civilized in the world. In another country, we find brawny rustics, owning their houses and lands, procuring by their labor all that is indispensable to them. No one among them falls short of a certain degree of ease and education, but no luxury can be seen anywhere. That country is considered very backward. Such are the habitual judgments of the day. I believe them to be superficial and false.

Bastiat suggests, in his "Harmonies Économiques," that we can not find a solution to the questions raised by the introduction of machinery and external competition while we consider want as an invariable quantity; we must admit that our needs are indefinitely expansible, and invoke luxury to afford an opportunity to put surplus labor to use. Machines, the economists of this school reason in effect, abridge labor; the more they are multiplied and perfected, the fewer hours of labor are required to obtain the same products. Thus the demand for hands is diminished, and an increasing number of workmen are put out of employment. In order to keep these men at work, new wants must be invented as fast as actual wants are satisfied by a smaller amount of effort, so that the hours that have been placed at our disposition may be utilized.

I claim that we ought to ask that the time that has been gained by the increased productiveness of machinery should be devoted, not to the creation of superfluities to satisfy factitious demands, but to the cultivation of the mind and the enjoyment of society and of the beauties of art and nature. At present the effect of machinery seems to have been not to shorten but to lengthen the hours of toil, and to extend them through the night, and to make life more intense and cause a greater expenditure of nervous force.

To satisfy our rational wants we require food, clothing, and habitation suitable to the climate and season; to these we may add the cheap accessories which the progress of industrial art has put within the reach of all. The line between a consumption that is reasonable and one that is not so may be found in every case by answering the question whether the satisfaction which the desired object will procure is worth the time and effort necessary to produce it. If it is, I am right in procuring it; but, if to get it I have to divert human labor from a more useful destination, I am wrong. I sacrifice what is necessary to what is superfluous. M. Baudrillart regards everything superfluous as a luxury. I agree rather with M. J. B. Say, who thinks it must be also dear. Thus, a Japanese fan costing a cent or two and a cheap looking-glass are superfluous; but, as it costs but little effort to get them, the satisfaction they afford is quite worth the expenditure. When the countryman drinks his wine which he would sell, perhaps, at four sous a quart, it is not extravagance. When a Crœsus drinks Johannisberger at eight dollars a bottle, the expense is relatively little for him; but he has, nevertheless, consumed the equivalent of twenty days of labor, which have been taken from the whole of the time available to humanity for the satisfaction of its essential wants, and for what advantage? Only to secure the fugitive taste of a flavor that is hardly appreciable to the finest palates. No one will hesitate to say that the time has been put to a bad use. The fact escapes the world under the complications of exchange; nevertheless, people have an intuition of it, for they often blame certain

foolish expenditures even when they are incurred by those who can afford them.

We may consider luxury from three points of view: First, from the moral point, as concerning the individual; within what limits is the perfect satisfaction of wants useful in the normal development of the human faculties? Second, from the economical point; to what extent is luxury a help or a hindrance to the increase of wealth? Third, from the point of right and justice; is luxury compatible with the equitable division of products, and with the general principle that the remuneration of each person ought to be proportional to the amount of useful labor that he has performed? The third aspect of the problem has hardly been appreciated, because it has never been clearly seen that juridical principles should be applied to the economical repartition of products. We should not forget, however, that Christianity, having made charity a duty, has always condemned luxury because it devotes to superfluous and therefore immoral expenditure that which ought, according to its principles, to be given to the poor.

Putting aside the consideration of what man owes to his fellows, and what charity and justice expect of him, let us see whether luxury is good or injurious to the individual. The end to be pursued by man in his life is the normal development of all his faculties and the happiness that should result from it. It includes the perfection of his physical and intellectual forces, of his sentiments, of his affections in the family and toward his race, and the enjoyment of the beautiful in nature and art. Modern luxury, with the multitude of efforts required to satisfy its demands, opposes a double inconvenience against the attainment of these objects. Time has to be consumed in gaining the money that its futilities require, and the leisure that is left after the money is got is employed in expending it upon them. The whole man is thus entangled in a wheel-work of material pursuits, and can afford nothing for the life of the mind and the heart. Consider the life of that financier who counts his millions by the hundred: his transactions, his calculations, his business associates, take up his whole day; and even in the evening, among pleasures which he seeks and does not enjoy, he is still thinking about operations that may increase that fortune the revenue of which already surpasses by many times the cost of all the wants that he can dream of. He may be said to be loaded down under the mass of his property. He may be without doubt a useful wheel in the general work of production, but is he on the road that leads to perfection and happiness? The man without wants is without cares, and may be gay as the lark all the day. By help of the gifts of science and art we are able to produce so much wealth that we are confounded at the sight of the figures by which it is measured in the statistical tables; and still our age is preoccupied, tense, and melancholy.

Bossuet treats this point in his "Traité de la Concupiscence" in language of great force: "The body," he says, "humbles the sublimity of our thoughts, and attaches us, who ought to breathe of heaven, to the earth. . . . Why," he continues, "do you turn your necessities into vanity? You need a house as a defense against injury from the weather—it is a weakness. You need food so that you can repair your forces, which are wasting away at every moment—another weakness. You need a bed where you can rest in your weariness and give yourself up to a sleep that chains and overwhelms your reason—another deplorable weakness. You make of all these witnesses and monuments of your weakness a spectacle for your vanity, and it seems as if you wished to triumph with the display of the infirmities that environ you on every side." Bossuet, it may be, carries the doctrine of renunciation to asceticism, but is he not right in the main? Is not every one of our needs a weakness, a subjection, a temptation to sacrifice the good and the just to sensuality? Dignity of bearing, pride in conduct, fidelity to opinion, often depend on simplicity in life. The fewer wants one has, the freer will he be to do whatever duty commands, and the less will he have in important crises to listen to the suggestions of cupidity.

The opinion that luxurious expenditure promotes the prosperity of the people is an error of the most pernicious character. Those who indulge in superfluities imagine that they are doing a service to the working people, and governing bodies, sharing in the delusion, sometimes grant special appropriations to induce certain functionaries to set the example of costly outlays. The most elementary notions of political economy should show this idea to be false. The progress of industry depends on the increase of capital, and capital grows with saving. Luxury does not promote the increase of wages, but opposes it. Wages can only rise when capital increases faster than the number of workmen, or, as Cobden says, when two masters are running after one workman. Now, in order that this may take place, each of the competing employers must have accumulated a capital by saving. It is thus saving, not superfluous expenditure, that permits the creation of new fabrics and the employment of more workmen. In very rich countries, indeed, luxury does not prevent the increase of capital, because the incomes are sufficient there to answer for both purposes. Those who save are found in those countries along with those who spend, and the possessor of a large income may easily indulge some of his fancies and still save considerable sums. The immense surplus revenues of England are employed in the creation of new enterprises at home and abroad; but, if thrift were more general in that land, its productive capital would be still more largely increased and more widely distributed.

It is claimed, as a thing that is admitted by every one, that luxury stimulates trade. J. B. Say shows up this doctrine with the story of

a rich uncle of his, who, after dining, broke his wineglasses, saying that the world must live. Say wondered why it would not be as well to break the rest of the furniture, to help more of the world's workmen to live. According to this view, Nero was inspired by true economical principles when he sung over the burning of Rome. M. de Saint-Chamant once remarked that, if Paris should be destroyed by fire, he would deplore the event as a citizen, but rejoice over it as an economist, for it would give an extraordinary bound to labor. If the doctrine be true, political economy should be the science, not of the production, but of the destruction, of wealth. The error arises from regarding labor rather than its results as the chief object.

To clear up this error, it is necessary, as Bastiat says, to distinguish between what we see and what we do not see. We see the workman who is engaged in replacing what has been destroyed, but we do not see the other workman who might have been employed to make something else with the money which we now have to apply to the payment of the former workman. Say's uncle certainly furnished work to the glass-factory, but if he had saved his glasses he might have spent the same amount of money in buying other things, and himself had more objects, while the wealth of the state would have been increased. Many hands were employed in rebuilding the monuments that were destroyed in Paris in 1871 ; but with the money that was thus spent other monuments, schoolhouses, or railways, for example, might have been built, and at the closing up of the account Paris would still have had its palaces, and the state would have gained new halls of instruction and new means of transportation.

It may be urged that, if our theories are carried out, hosts of tradesmen and artisans will be condemned to starvation. The value of this objection may be illustrated by an hypothetical example in life. A wealthy banker spends immense sums in feasts, and induces his friends to spend three or four times as much as he does. The dealers to whom patronage is given accumulate great sums. The public is charmed, trade flourishes. Now comes a preacher thundering against luxury, and instigating a revival of frugality. Balls and feasts are given up. What will be the result of the change? The banker and his friends are not going to throw their money away or let it be idle, but will do something with it to make it return a profit. One will improve a long-neglected piece of land, will plant and drain it, and repair the buildings; another will enlarge his factory, and a third will undertake railway contracts. All will make work, and that of a useful and productive character, so that they may receive interest for their outlays. The same amount of money is spent, and it supports the same amount of work and gives a living to the same number of workmen, only they are employed in the fields, where they are not seen, instead of being engaged in the fashionable shops, where they are always before the eye of the public. Now look at the difference in the effect on the

wealth of the country. When the ballroom lights were put out, what was left? Nothing but rumpled vanities, deranged stomachs, and overtaxed nerves. The capital of society has been twice diminished: in the expenditure of money and the waste of human force. On the other hand, when the useful enterprises which have given as much work are finished, there remain a field better drained and manured and bearing more grain, a better planted forest furnishing more wood, a new factory turning out more goods, and a new railway line. The country is enriched and produces more. In the next year the workmen are better provided for, their expenses are lessened, more hands are needed to keep the increased capital employed, and wages are raised. A profit has accrued on both sides. The application of means to the production of necessary and useful objects has the additional advantage that the demand for such objects is more stable, that they are not so readily dispensed with in times of retrenchment, and are not so subject to the changes and caprices of fashion.

It is further pleaded that luxury makes money circulate. This, also, is unsound. Circulation of itself brings no profit. Money nowhere circulates faster than on the green cloth of the roulette-table. Some lose, others gain, millions; but what is the profit to the country? Money is all the time in circulation, unless it is buried in a pot. The important matter is, whether in passing from hand to hand it commands permanent ameliorations and satisfies the real wants of men, or whether it is wasted upon the futilities that minister to pride and ostentation.

The crowd approve the letting off of expensive fireworks, and believe that the money they cost is still in the country, and that nothing is lost. But there were in the country two capitals: one of money, the other represented by powder, which might have been employed in extracting coal and minerals from the earth, or in works for railways. The second capital has vanished in smoke, and only the money is left. Consumption is always destruction; it is important to see that for this destruction is returned as compensation some satisfaction of real wants, or the creation of some new means of production. Consumption is in reality a barter. We give up an existing value; if we receive in return something to strengthen the body and exalt the soul, we have done well; if something to stimulate pride and vanity, it is worse than nothing, and we have done ill.

We may regard luxury, in the third place, from the juridical side, and ask if it is compatible with right and justice. All Christian tradition answers the question in the negative. The Scriptures abound in passages condemning the egotistical and unregulated employment of riches. The fathers of the Church insisted upon a kind of equality of right, and urged that those who have a superfluity can not legitimately dispose of it for themselves, but ought to share it with those who are in want of necessaries. The Church has indicated alms as the

single remedy for inequality of wealth and its resultant luxury. What is to be done, however, now that political economy has demonstrated, from the evidence of facts, that alms engenders idleness, mendicity, indolence, and debasement of character, and that it is fundamentally wrong, because it levies an impost on those who work for the profit of those who do not work?

The true solution of the question is to be found in encouraging the greatest possible number of citizens to become holders of property. Let it be in the power of each one to secure a parcel of land, a bond, or an industrial obligation, a little capital in some form, so that property may become democratized, and extreme inequality will be caused to disappear; then, if the progress of mechanical arts induces the multiplication and refinement of products, they will be within the reach of all. Such conditions still prevail in countries where the agrarian customs and the proprietary forms of primitive times have not been destroyed by the civil laws and feudal and royal usurpations.

Voltaire says on this subject, in his "Dictionnaire Philosophique": "If we understand by luxury all that is over and above the necessary, it is a natural consequence of the progress of the human species, and by a consequent reasoning every enemy of luxury should believe, with Rousseau, that man's real state of happiness and virtue is not that of the savage, but of the orang-outang. We feel, however, that it would be absurd to regard as evils such conveniences as all men enjoy; so we generally give the name of luxury only to the superfluities which are within the reach of but a small number of persons. In this sense, luxury is a necessary concomitant of property, without which no society can exist, and of a great inequality in fortunes, which is the result, not of the right of property, but of bad laws. It is, therefore, bad laws that generate luxury, and it is good laws that must destroy it. Hence, moralists should address their remonstrances to legislators, not to individuals; for it is in the order of possible events that a virtuous and enlightened man should have the power of making reasonable laws, but it is not in human nature that all the rich men of a country should virtuously give up the enjoyment of buying pleasure and vanity at the price of a small sum of money."

One kind of luxury only, in my opinion, is justifiable: that, namely, which admits the public to its enjoyments; which invites the masses to the pleasures of public gardens and fountains, which places the beautiful within the reach of those who can not own statuary or pictures, by establishing museums of art, and which founds libraries and public expositions. Such collective luxury, if well directed, is profitable to all. It raises the level and fecundates the genius of industry. The duty of the easy classes in every country is to favor those movements which will tend to enable all of the people to become possessors of property, and themselves to set the example of application to labor, rural tastes, simplicity of life, and high moral and intellectual cul-

ture. Those who have the disposal of the superfluous produce of the country should employ their wealth not in refining material enjoyments, or in stimulating the unhealthy gratifications of vanity and pride, but in works of general utility, as many an American citizen and more than one European sovereign have done.

MIND AS A MEASURE OF NATURE.

By CHARLES T. HAVILAND.

IT has been said that every man is born a Platonist or an Aristotelian. This is an epigrammatic way of stating the fact that the general tendency in the pursuit of knowledge is to approach it from one or the other of two different standpoints, variously called the subjective and the objective ; the mental and the material ; the theological, or metaphysical, and the scientific. While this tendency is pretty clearly marked, yet the saying has the fault common to most apothegms, of sacrificing correctness to brevity—of overlooking the delicate gradations in Nature's continuity in its attempt to express her more salient diversities in a pithy utterance. This is the imperfection of all classifications. They necessarily separate what is continuous. It is only as they refer to genetic relationships that they most nearly correspond with nature, and this they can do in only a few of the natural sciences. For the most part, the act of classifying is the application of a mental scale to incommensurable quantities. The very impossibility of grouping phenomena into natural kinds renders an artificial classification necessary. Before science can advance a single step, the innumerable phenomena of nature must be reduced into classes. If not susceptible of natural arrangement, they must be arranged artificially ; and, as long as the artificial character of the classification is comprehended, no harm is done ; but when men, with but little knowledge of the objects dealt with, proceed to construct a procrustean bed to which they expect Nature to conform, and then, from this tortured witness, attempt to extort unwilling testimony, they may expect Science to enter a demurrer. As this method, however, has the merit of simplicity, as might be expected, it has long been the favorite with a certain class of philosophers.

Turning back to the early progress of human speculation, especially so far as it has reference to material objects, we see that all the first attempts at physical knowledge consisted, principally, of deductions from mental notions, with but little, if any, reference to phenomena. Beginning with the theories of the universe propounded by the Greek philosophers, we see that whatsoever progress was made in scientific acquisition was only in proportion to the occasional reactions from the

excessive subjectivity that mostly prevailed. This reaction found expression in men like Archimedes and Hipparchus, and under their influence science had apparently attained a foothold when the intolerance of a religious supremacy, which held sway over Europe during the dark ages, banished it from Christendom, and thus became debited to humanity for a thousand years of stagnation.

Not until the time of Copernicus was there any new impetus to research. The appeal to objective facts was, then, although in a small degree, made the avowed basis of scientific speculation. Then began the progress of knowledge which, with constantly accelerating speed, has continued to our times, and which, we trust, may not again be slackened.

The experience of our predecessors teaches us a lesson that we ought not soon to forget. In the practical affairs of life, experience is considered the best guide. The man who learns nothing from its teachings does not succeed. It is no less important in the life of the race. If we learn nothing from others' failures, we can expect to learn nothing from their successes.

The attempts to construct the universe *a priori* are analogous to the attempts to construct a perpetual motion. As long as there was no direct reference to experience, it appeared by no means improbable that a machine might be so constructed that, when once set in motion, it would never stop. Any one, who has had any experience with a class in mechanics, knows how crude are the notions they possess with reference to the very elements of physics. It is safe to assert that today not one person in ten possesses a thorough certainty of belief in the validity of the third law of motion, namely, that action and reaction are always equal; or, to put it in more familiar language, that, when a horse pulls a wagon, the wagon pulls the horse equally hard. It is not until correct mechanical notions become wrought into the very warp and woof of one's mental fabric that his deductions from them may fairly be presumed to be correct. Witness the absurd notions current only a very few years ago as to the possibility of constructing a "motor" that should, in some mysterious way, evolve force enough from a pint of water to propel a train of cars from Philadelphia to New York! Mechanics went on inventing "perpetual motions," but, however plausible they looked, somehow or other they wouldn't work. Do away with friction to the greatest possible extent; overcome one obstacle here and another there; increase the time the machine would run indefinitely—still, to a state of equilibrium would it come at last. From these empirical observations mechanics learned, what philosophers might have learned years ago, that experience affords the only sure test of the validity of our notions.

After numberless failures had taught the empirical lesson that attempts to construct a perpetual motion were fruitless, the gradual development of the law of the conservation of energy showed the reason

for it. In like manner, we have sufficient reason, judging merely from the observation of previous speculation, to warrant us in abstaining from attempts to deduce a knowledge of material nature from mental concepts. Add to this fact that other, that all knowledge has its basis in experience, and we supplement our empirical conclusion by a deduction from a fundamental law of nature, and show their entire congruence.

Early physical speculation, with hardly an exception, proceeds on the assumption that knowledge is derived primarily from the mind—thus completely inverting the true order. Would some of those persons who in our day attribute so much power to the unaided mind carefully peruse a history of science in the early centuries of our era and the centuries immediately preceding it, we think they would become convinced that purely mental speculation can never lead to any exact knowledge, but must, on the contrary, invariably be a source of obscurity and error.

With but two or three exceptions, the most eminent men of the early and middle ages, except as in a few instances they recorded interesting facts, contributed absolutely nothing to scientific progress. The principal cause of the difference in the civilization of our times and those of the ancients is the progress of exact knowledge. What would the most mystical of metaphysicians of to-day say to Socrates's assertion that those things are called like which partake of the quality of likeness? or to Aristotle's argument against a void in nature, that a void is a negation, and in a negation there could be no differences, and where there were no differences there could be no up or down, consequently bodies could not move up or down in a void, but it is the nature of bodies to move up and down, therefore there is no void? or to his argument in support of circular motion, that it is the best, therefore the most natural? The mental ability of the "Father of Logic" is unquestioned. He follows logical methods closely enough. What, then, is there unscientific in his reasoning? Simply that he allows abstract terms and mental notions to pass current for facts—thus using an irredeemable currency as though it possessed intrinsic value.

The modern astronomer can not but wonder at the daring speculations of the Pythagoreans, that, as ten was a perfect number, there must be ten heavenly bodies, notwithstanding nine only were then known. Before such vaticinations the predictions of a Leverrier sink into insignificance.

We find the whole history of science, up to the time of Copernicus, a history of the conflict of facts with preëstablished notions. The problem of astronomers was to reconcile the apparent motions of the heavenly bodies with their assumed circular motions. Thus, when it was found that the motions of the planets were not uniformly circular, it was naïvely suggested that an uncertain motion could not be

tolerated even in a man, much less in a planet, hence the theory of epicycles, or wheels revolving on the rims of other wheels, was introduced. Notwithstanding its questionable parentage, and the fundamental error on which it is based, this theory, as established by Hipparchus and extended by Ptolemy, is about the only example of a scientific working hypothesis previous to the fourteenth century.

Physics, equally with astronomy, suffered from the anti-scientific method. The study of nature was not only neglected, but discountenanced by the Church. *A priori* arguments were urged against the existence of antipodes, and, but a short time before they were visited by Columbus, a belief in their existence was denounced as heretical. The direction of knowledge during the middle ages was retrogressive rather than progressive. Scholastic physics was based upon the assumption that analysis of mental concepts would give all requisite knowledge. Why wonder at the result? Weight being the cause of bodies falling, it was assumed that heavy bodies would fall faster than light ones. Personal qualities being attributed to inanimate objects, there were supposed to be different degrees of perfection in the metals, and thus arose alchemy, whose aim it was to extract gold—the most perfect metal—from the baser metals.

The contagion of scholasticism became epidemic, even infecting able men, and establishing its parasitic growth upon sound theories. Astronomy gave birth to astrology, to whose weird influence even a Bacon could succumb. One of the arguments brought forward in support of the Copernican theory was that it placed the noble element, fire, in the center of the universe, thus satisfying the tendency toward mythical explanations. So prevalent was this method of considering nature, that Kepler himself entered into complex speculations concerning the relations of music to the motions and distances of the planets; and even Galileo was led into an erroneous theory of motion in consequence of assuming that it must be the simplest possible. In support of true hypotheses, as well as false, metaphysical reasons were given. The fact that from them anything wished for can be proved, constitutes the great danger in their use. From the immutable laws of God Descartes deduced the first law of motion, while, from the same source, the Church had previously demonstrated the immovability of the earth. Borelli conjectured that the motions of the planets were controlled by two forces—one the centrifugal force, and the other the appetite a planet must have for the body about which it revolves. Suction was explained by the famous principle that Nature abhors a vacuum, and, had it not been discovered that the abhorrence ceased at certain fixed limits, this explanation would probably have done service even to our day, for that class of philosophers for whom the kindred principle of vitality is a sufficient explanation of the various phenomena of life.

The few examples that have been cited give a fair sample of the science of the middle ages. During that long period the men imbued

with a spirit of scientific research could be counted on one's fingers. It is a striking fact in the history of man that, out of the many centuries he has inhabited the earth, so few have been productive of any useful knowledge. Throw away everything that had been done previous to the fifteenth century, and the loss would have been by no means irreparable. Add to the productive period twenty centuries, and we embrace the whole. Think of the average life of fourscore men spanning the totality of human knowledge! Truly, science is in its infancy. What were the speculations of the men who existed a few centuries prior to our era, we have no record. After the dim poetical aspirations which compose the earliest known philosophy, there emerges a pseudo-scientific natural philosophy, which, disdaining the shackles that a constant reference to the phenomena of nature would impose upon its flights, attempts at once to solve the problem of the universe. Like the famous German, who, instead of going to see the camel he was to describe, pursued the easier and more fascinating method of evolving him from his own inner consciousness, the Greek philosopher evolved the universe from his.

A modern writer, who certainly can not be accused of want of sympathy with a deductive philosophy, in comparing the relative merits of the *a priori* and *a posteriori* methods, observes that, although the latter may in general come somewhat nearer the facts of nature, yet, as it can never embrace *all* the phenomena in its inductions, it can never arrive at the whole truth; while the *a priori* method, if it chance to hit upon the right formula, has the whole universe, so to speak, at its fingers' ends. While we may readily admit the sublimity of the attempt to reach out and grasp the hidden springs of nature, stubborn facts constrain us to assert its impracticability. The diffuse light of mental theory must be concentrated to a small focus in order to produce any visible effect.

Knowledge is the concomitant of the progressive limitation of our powers. As long as man assumes that he contains within himself the premises of knowledge, so long will it elude his grasp. Not until experience has compelled him to doubt the validity of his mental concepts when applied to nature, and has forced him to have recourse to facts only, has man taken the first steps in the paths of science.

That one learns the boundlessness of knowledge only in proportion to his own acquirements is a saying famous only for its triteness. What are certainties to the ignorant are uncertainties to the intelligent. What are dogmas to the blind followers of a fanatical priesthood are for ever insoluble problems to the man of science. The ignorant savage—who can not count beyond five; who has no abstract names in his vocabulary; who knows nothing of the use of pronouns; who uses words denoting the commonest things and most usual actions only—possesses knowledge differing so widely in degree from ours as almost to constitute a difference of kind. For him nature has no problems.

The universe, of which he knows so little, is but in a slight degree a mystery. Wonder—the first sense of philosophy, as it has been so aptly termed by Aristotle—exists in his mind only as superstition. We are too apt to think that primitive or savage man must be appalled by the presence of nature, forgetting that his universe is limited to his own unaided senses. We forget that, in our own life, philosophic problems present themselves only as we approach maturity, and, generally, then only if our studies have led us in their direction. To see how little the "natural man" comprehends these problems, observe the answers he gives to those questions in which it is customary to assume that the wayfaring man, though a fool, does not err.

Man is naturally a "realist." Things *are* to him what they seem. Mind is his sole measure of nature. He looks nowhere else for an interpreter, and knows no other source of knowledge. He interprets natural phenomena by mental qualities, and this prepossession colors all his theories. The history of science is the history of the gradual demolition of this tendency. The mental distance from a savage that personifies the tree, the forest, and the stream, to a Kepler that conceives it necessary to place a guiding spirit in the planets to keep them in their courses, is, of course, immense, and each is indicative of the thought of his time; but we now know that each was in error in positing some utterly unknowable substance to explain the unknown elements.

The person who to-day expects to make the phenomena of life more clear by attributing them to the effects of "vitality" is making a dangerous mental concept do duty in place of exact knowledge, however limited. The frequency with which this attempt occurs, even among men eminent in science, shows that continued protests are needed. However little real knowledge we may possess upon a given subject, our only way to get more is to approach it humbly and laboriously as a question that can be solved only by constant reference to the facts that appertain to it. All experience teaches that an analysis of mental notions has never yet yielded a particle of natural knowledge, but, on the contrary, has often proved a barrier to the acceptance of true theories. We can not expect to be more fortunate ourselves. The principal objection to the development theory has been on the ground of its opposition to preconceived notions as to the reality of the mental conception "species," and to certain beliefs in vogue concerning the genesis of man, rather than to its assumed opposition to the facts of nature. Every theory has to run the gantlet of this extra-scientific criticism, and only when it is shown to have no possible bearing upon preconceived notions is it allowed to be settled simply upon its merits and by scientific methods.

Instead of reverting to the experience of our ancestors and showing the futility of all previous attempts to extract light from mental sunbeams, we might have deduced the same conclusion from the known

laws of thought. No psychological theory has greater probability than that which bases the units of knowledge in experience. Since the time of Locke and Hume, the drift of speculation has been steadily in the direction of a more or less modified empiricism. The more far-sighted of the intuitionists cast aside everything they thought could embarrass their theory, and were content to allow that the matter of thought was based upon experience, while reserving as the province of intuition the mental forms by which knowledge was possible. The theory of evolution explains this intuitional residue by extending the experience of the individual to the experience of the race, and showing that what may be intuitive (in every sense, except the supernatural, in which that word was formerly used) to the individual is so in consequence of inherited tendencies corresponding to the aggregate experience of his ancestors.

But we do not need to urge mental theories, however probable, to show that our knowledge of the universe is dependent upon our surroundings. A little difference in the physical condition of the earth would have sufficed to have utterly changed our conception of nature. Make the not very inconceivable supposition that our earth bore the same relation to the sun that the moon does to the earth—rotating once on its own axis to each revolution about the sun, and remaining nearly perpendicular to the ecliptic, thus always presenting the same side to the sun's rays—how would it have affected our knowledge of nature? To what modest proportions would not only science have shrunk, but also our mental or intuitive conceptions of nature!

Astronomy has been well called the mother of the sciences. The apparent motions of the sun, moon, and stars through the heavens, and the motions of the planets among the stars, contributed to produce a wonder in the minds of the beholders that might well cause astronomy to be the first studied of the sciences. In our hypothetical world, the sun would appear stationary in the heavens, more or less removed from the zenith according to the position of the observer. On the center of the earth's surface would be a torrid zone upon which the vertical rays of the sun would pour down with unremitting severity, with no alternation of day and night to temper its influence. Outside of this would be a temperate zone well adapted, it might be, to the existence of human beings, but having no change of seasons, only one monotonous summer day, varying in temperature according to location. The temperate zone would gradually give place to a frigid zone, and, as the day darkened into an eternal night, this would be succeeded by an impenetrable region in which the degree of cold would vastly exceed anything we have on earth at present. Thus man, confined to somewhat less than half the globe, would see nothing of the moon or stars, and the earth, with the sun shining on it, would be the only bodies visible. There would be no natural divisions of time into days, weeks, months, or years. Mathematicians might calculate the hemispherical

form of the earth, but the elephant and the tortoise would be more than ever necessary to support it. There would be no science of astronomy, no knowledge of the law of gravitation, none of physics, so far as it was dependent upon astronomy. The sciences so act and react on one another that it is difficult to say just how far the absence of one would affect the others, but we know it would greatly. Such suppositions as we have made may be more or less fully realized in other worlds, and we can thus see that their science may differ very widely from ours and still be no less correct. Science is everywhere relative to the facts with which it has to deal. The difficulty of conceiving physical and spatial relations different from those we are familiar with does not prove them non-existent; nor does the ease of such conceptions prove their existence.

Helmholtz has very ably shown that our geometrical axioms have a truth relative only to the space they are applied to. He supposes beings, of the same mental capacity as ourselves, but of two dimensions only, to inhabit a plane surface. They would possess a plane geometry like ours, but would have no solid geometry whatsoever. Thickness would be as inconceivable to them as a fourth dimension in space is to us. Transplant these beings to the surface of a sphere, and their planimetry would change to a spherical geometry. Defining a straight line as the shortest distance between two points, all their straight lines would be arcs of great circles, and every straight line, when sufficiently extended, would return to itself. Between two points, half the circumference of a great circle apart, an infinite number of straight lines, of equal length, could be drawn; and, as two points would always cut the great circle on which they were situated into two arcs of unequal length, there would always be, besides the shortest straight line connecting the points, a longer straight line (i. e., a line made up of shorter lines, each of which is the shortest distance between its extremities) also connecting them. There could be no parallel straight lines and no similar triangles. The sum of the angles of a triangle would always be more than two right angles, and the amount of the excess would depend upon the length of the sides.

Helmholtz again supposes these beings of two dimensions to be placed upon (what has been called by Beltrami) a pseudo-spherical surface—a surface shaped somewhat like the sides of an hour-glass. Here our axiom of parallels does not hold good. Through a given point, a whole pencil of straight lines may be drawn, none of which shall cut a given line, though infinitely produced, and limited, at the two extremes, by lines that cut the given line at infinite distances in the opposite directions. Helmholtz makes other suppositions which it is unnecessary to follow, as we have already gone far enough to show that even the fundamental axioms of geometry are quite as dependent upon the conditions under which they are used as upon any intuitive necessity we may think belongs to them.

It is well known that but a portion of the phenomena of nature are cognizable by us—how small a portion it is not known. A person born blind has no conception of color; one born deaf, none of sound. The disease of color-blindness affords a good illustration of the limitation of knowledge in consequence of the limitation of sensibility in certain directions. One affected with this disease, while able to see outlines with perfect distinctness, as well as some of the colors, is insensible to others; and this insensibility does not affect alone the ability to discriminate between colors nearly alike, but also those that are apparently widely divergent. It is related of Dalton, from whom color-blindness takes its name of *daltonism*, that some wag exchanged the robe of sober drab which this demure Quaker was in the habit of wearing, for one of scarlet, and that, unconscious of the difference, he went forth, much to the amusement of the bystanders. Undoubtedly many accidents are due to the inability to discriminate between different colored signals. This subject is just beginning to receive the attention its importance demands, and it is found much more prevalent than was even suspected. Like short-sightedness and, probably, all maladies due to the absence or the imperfection of any of the senses, the subject of it is unconscious of its existence until something particular calls it to his attention. To a greater or less extent we may all be said to be color-blind. Only a part of the rays that are known to proceed from the sun are visible to any of us. Vision is produced only by waves of a certain definite length. The rays of longer wave-length than the red are known to us by their heat-producing effects only; those of shorter wave-length than the violet, by their chemical effects. It is not improbable that, at some future time, a race may exist capable of seeing rays invisible to us—just as we perceive many invisible to some of the lower animals. In the development of sight there must, at first, have been simply a power to distinguish light from darkness; then, the ability to distinguish outlines; and, finally, the sensibility to color. Until this sensibility was developed, objects would present merely an alternation of light and shade, similar to the view we get in a stereoscopic picture.

Sounds inaudible to us are heard by insects, and odors that we can not distinguish are smelled by animals. So we might go through the whole category of sensations and resulting ideas, and show their variation under different conditions; and yet, whatever may be the theory of knowledge we espouse, it is from these sensations and ideas that we form our conception of nature. How different our mental conceptions would be if our senses were indefinitely magnified, we can but guess. A drop of water, it has been estimated by Sir William Thomson, if magnified to the size of the earth, would be seen to consist of molecules of the size of cricket-balls; and these molecules are themselves of great complexity. The internal motions of a drop of blood are more complex than the motions of the solar system. Place

it under a microscope of high power, and the corpuscles are seen hurrying hither and thither as if (to use a quite appropriate simile) their life depended upon it. Repeat the process, and new complexities are seen. Increasing the power of our senses artificially by the use of instruments has given us a vastly enlarged conception of nature; but every increase in knowledge shows us more clearly the limitation of the knowledge we possess. Truly, there are more things in heaven and earth than are dreamed of in our philosophy.

Science is continually teaching us the lesson that the universe is larger and more complex than formerly supposed. Old geographers, guided by an egoistic impulse, placed their own country in the center of the known earth; early astronomers placed the earth in the center of the universe. Later, that position of honor was given to the sun. The influence of mental concepts and the desire for system, even where none is discernible, induce some astronomers to locate the center of the sidereal system somewhere in the region of the Pleiades; but, even should this attempt prove successful, we should be no nearer the discovery of the center of the universe. Place a grain of sand thirty feet from an orange, and you have, approximately, the relative distances and dimensions of the earth and sun. Nearly one thousand feet beyond would be the planet Neptune—the outermost planet of our system—while more than twelve hundred miles would have to be traversed before arriving at the nearest fixed star. Even on this miniature scale, our fractions of inches grow to miles, and man finds himself immeasurably dwarfed, even in the presence of the known. He sees whole systems drifting through space. In a much broader sense than Emerson meant, we are like ships upon an unknown ocean, knowing neither whence we came nor whither we are bound.

It is fascinating, no doubt, to construct theories of universe-reaching proportions. It has been truly said that—

> "... Our nimble souls
> Can spin an insubstantial universe
> Suiting our mood, and call it possible,
> Sooner than see one grain with eye exact,
> And give strict record of it."

Perhaps such employments are elevating. Such, at least, is the claim of those who affect to despise what they superciliously term the bread-and-butter sciences. Admit all they claim; still, their conceptions of nature are worthless until verified.

In this brief sketch of past thought, we have seen that it was only as man has been content to acquire knowledge patiently, slowly, and arduously, by what are now known as scientific methods, that his knowledge has been of any practical value. Theorize as widely as he may, constant verification is the only criterion of a theory's validity. Fact must be the point of departure and the point of return of all

theories. Mental notions can aid us only as they are reflections of nature. Even scientific hypotheses have but a relative validity. In time, as in space, the extent of knowledge follows a law analogous to the law of spherical diffusion. It has been held that the record of any historic event is wholly invalidated by the lapse of sufficient time; much more is this true of future prediction. The base-line of our knowledge is sufficient but for a limited survey. The very distant future has no mental parallax.

We have seen every far-reaching theory become obsolete; and there is no reason to suppose that, at the present time, we shall be more successful. There is but one course that it is safe to pursue, namely, to be content to let insoluble problems remain as such—not attempting any mental theory concerning them—and confine ourselves to those problems that may offer some probability of solution, with the assurance that, however far the boundaries of knowledge may be extended, each successful solution will enlarge the horizon of the unknown beyond.

SKETCH OF PROFESSOR BENJAMIN PEIRCE.

THIS illustrious American mathematician and astronomer died in Boston, October 6, 1880, in the seventy-second year of his age. He was born in Salem, Massachusetts, April 4, 1809. He was graduated at Harvard College at the age of twenty. His father was a graduate of the same institution, and died its librarian. He was appointed tutor in 1831, University Professor of Mathematics and Natural Philosophy in 1833, and Perkins Professor of Astronomy and Mathematics in 1842, and was directly connected with the faculty of the college for forty-nine years. He was a member of all the learned societies in this country and in Europe, was elected Fellow of the Royal Society of England in 1857, and in 1867 received the degree of LL. D. from Harvard University.

We take the liberty of quoting from that excellent periodical, "The Harvard Register," for May, 1880 (to the courtesy of whose editor we are also indebted for the excellent likeness herewith presented), the following account of Professor Peirce's character and work, written, it will be observed, before his death, by Dr. Thomas Hill, ex-President of Harvard University:

"From 1836 to 1846 he issued a series of text-books on geometry, trigonometry, algebra, and 'curves, functions, and forces.' They were so full of novelties that they never became widely popular, except, perhaps, the trigonometry; but they have had a permanent influence upon mathematical teaching in this country; most of their novelties have now become commonplaces in all text-books. The introduction

of infinitesimals or of limits into elementary books; the recognition of direction as a fundamental idea; the use of Hassler's definition of a sine as an arithmetical quotient, free from entangling alliance with the size of the triangle; the similar deliverance of the expression of derivative functions and differential coefficients from the superfluous introduction of infinitesimals; the fearless and avowed introduction of new axioms, when confinement to Euclid's made a demonstration long and tedious—in one or two of these points European writers moved simultaneously with Peirce, but in all he was an independent inventor, and nearly all are now generally adopted.

"All his writings are characterized by singular directness and conciseness, and particularly by a happy choice of notation—a point of great importance to the mathematician, lessening not only his mechanical labor in writing, but also his intellectual labor in grasping and handling the difficult conceptions of his science.

"His text-books were also complained of for their condensation, as being therefore obscure; but, under competent teachers, their brevity was the cause of their superior lucidity. In the Waltham High School his books were used for many years, and the graduates attained thereby a clearer and more useful applicable knowledge of mathematics than was given at any other high school in this country; nor did they find any difficulty in mastering even the demonstration of Arbogast's Polynomial Theorem, as presented by Peirce. The latter half of the volume on the Integral Calculus, full of marks of a great analytical genius, is the only part of all his text-books really too difficult for students of average ability.

"Gill's 'Mathematical Miscellany' contained many contributions which showed in a singular light the Harvard professor's power. For example, in the issues for May and November, 1839, he solved, by a system of coördinates of his own devising, several problems concerning the involutes and evolutes of curves, which would probably have proved impregnable by any other mode of approach.

"During the year 1842, Professors Peirce and Lovering published a 'Cambridge Miscellany of Mathematics and Physics,' in which Peirce gave an analytical solution of the motion of a top, a criticism of Espy's theory of storms, etc. About the same time he adapted the epicycles of Hipparchus to the analytical forms of modern science; and the method was used by Lovering in meteorological discussions communicated to the American Academy.

"The comet of 1843 gave Professor Peirce the opportunity, by a few striking lectures in Boston, to arouse an interest which led to the foundation of the observatory at Cambridge; and, by his discussions of the orbit with Sears C. Walker, he and that remarkable computer were brought to mutual acquaintance, and prepared for the still more important services to astronomy which they rendered after the discovery of Neptune. This planet was discovered in September, 1846, in

consequence of the request of Leverrier to Galle that he should search the zodiac, in the neighborhood of longitude 325,° for a theoretical cause of certain perturbations of Uranus. But Peirce showed that the discovery was a happy accident ; not that Leverrier's calculations had not been exact, and wonderfully laborious, and deserving of the highest honor ; but because there were, in fact, two very different solutions of the perturbations of Uranus possible : Leverrier had correctly calculated one, but the actual planet in the sky solved the other ; and the actual planet and Leverrier's ideal one lay in the same direction from the earth only in 1846. Peirce's labors upon this problem, while showing him to be the peer of any astronomer, were in no way directed against Leverrier's fame as a mathematician ; on the contrary, he testified in the strongest manner that he had examined and verified Leverrier's labors sufficiently to establish their marvelous accuracy and minuteness, as well as their herculean amount.

"A few years later, 1851 to 1855, Peirce published the remarkable results of his labors upon Saturn's rings. Professor G. P. Bond had seen the ring divide itself and reunite, and had thereby been led to show by computation from Laplace's formulæ that the ring could not be solid. Upon this Peirce investigated the problem anew, and showed that the ring, if fluid, could not be sustained by the planet ; that satellites could not sustain a solid ring, but that sufficiently large and numerous satellites could sustain a fluid ring, and that the actual satellites of Saturn are sufficient.

"In 1849 he was appointed consulting astronomer to the 'American Ephemeris and Nautical Almanac,' and rendered efficient service in bringing that publication to its condition of honorable authority, particularly in the lunar tables which he furnished, in his treatment of Neptune, and various methods of computation. He also assisted Professor Bache in the Coast Survey, and was, for many years, of great service in that important national work before he was himself appointed superintendent in 1867. His calculations of the occultations of the Pleiades were very laborious and exact, and furnished an accurate means of studying the form, both of the earth and her satellite. His criterion for rejecting doubtful observations is an ingenious and valuable extension of the law of probabilities to its own correction. His detection of the mental error of lurking personal preferences for individual digits is a curious specimen of that acuteness of observation which characterizes his own mind.

"He held the office of Superintendent of the Coast Survey from 1867 to 1874. Coming after such able men as Hassler and Bache, to an office which required not only familiarity with mathematics and physics, but also great knowledge of men and executive ability, he was not found wanting, but showed that the theory of the Stoics will sometimes hold good to-day—the really great man shows himself great by any and every standard. The Coast Survey has, since the year 1845,

steadily advanced in public favor, and its work commands the highest respect among all men competent to judge throughout the world, as being not only of direct service to the nation, but as making constant valuable additions to science.

"Many monographs, bearing the marks of Peirce's individuality and peculiar power, have been read by him before various academies, societies, and institutions; but only the results of most of them have ever been furnished for publication. Among these may be mentioned an investigation of the forms of stable equilibrium for a fluid in an extensible sack floating in another fluid, being an *a priori* embryology. Also, the motions of a billiard-ball, an instance in nature of discontinuity, when the ball leaves its curve, and goes on a tangent; another, the motion of a sling, curious from the immense variety of forms comprised under exceedingly simple uniform conditions.

"In 1857 he published a volume, summing up the most valuable and most brilliant results of analytical mechanics, interspersing them with original results of his own labor. A year or two later an American student in Germany asked one of the most eminent professors there, what books he would recommend on analytical mechanics: the answer was instantaneous, 'There is nothing fresher and nothing more valuable than your own Peirce's recent quarto.' In this volume occurs a singular instance of a characteristic which I have already mentioned. Peirce assumes as self-evident that a line which is wholly contained upon a limited surface, but which has neither beginning nor end on that surface, must be a curve reëntering upon itself. By means of this hyper-Euclidean axiom he reduces a demonstration, which would otherwise occupy half a dozen pages, to a dozen lines.

"In 1870, through the 'labors of love' of persons engaged on the Coast Survey, an edition of a hundred lithographed copies was published, of certain communications to the National Academy upon 'Linear Associative Algebra.' In 1852 Hamilton, of Dublin, had published his wonderful volume on quaternions; and this had been followed by various other attempts to create an algebra more useful in geometrical and physical research than the coördinates of Descartes. Ordinary algebra deals only with quantitative relations, and the object of the arithmetic of lines and of Cartesian coördinates had been to reduce distances and directions to a comparison of quantity. But Hamilton introduced quality also; and his algebra employed the dimensions of space, unchanged and essentially diverse, in computation. His imitators and followers had not succeeded in improving or in really adding to his methods. But Peirce, in these communications to the Academy, attacks the problem, according to his wont, with astonishing breadth of view and boldness of plan. He begins with a definition of mathematics, shows the variety of processes included in his definition, passes then to its symbols, shows the nature of qualitative and of quantitative algebras, and of those which combine the two,

and says he will investigate the general subject of algebra. First, he limits himself in this volume to algebras handling less than seven distinct qualities—that is, not exceeding six. The notation is then discussed, and the necessary enlargements and modifications of the algebraic signs and symbols are clearly defined. The distributive and associative principles in multiplication are adopted, but not the commutative; and he confines himself to linear algebras — that is, to those in which every expression is reducible to an algebraic sum of terms each expressive of a single quality. After a full discussion of the general results which must be found in all algebras under these conditions, he begins with single algebras, then double, then triple, and so on up to sextuple, making nearly a hundred algebras which he shows to be possible, and of which he gives the great features. There are almost no comments upon them; and it is only by a patient examination for himself that the reader discovers that, of all these numerous algebras, only three have ever been heard of before. First, of the two single algebras we have one, which is the common algebra, including its simpler form of arithmetic. Secondly, of the three double algebras, we have one, viz., the calculus of Leibnitz and Newton. Thirdly, of over twenty quadruple algebras, only one has been used, the quaternions of Hamilton. Such is a brief abstract of this book of marvelous prophecy. The most noteworthy things which he has done since its publication are a course of Lowell lectures, given about a year ago, on 'Ideality in Science,' and a series of communications to the American Academy, which, it is understood, is still to be continued. In the Lowell lectures he embodies many of his views on philosophy and religion which are peculiarly dear to him, and are always listened to with profound interest, even by those of less religious nature. In the communications to the Academy he is discussing, with all his wonted power, questions of cosmical physics, and particularly theories concerning the source and supply of the sun's heat.

"While Professor Peirce has the tenacity of grasp and power of endurance which enable him to make the most intricate and tedious numerical computations, he is still more distinguished by intensity and fervor of action in every part of his nature, an enthusiasm for whatever is noble and beautiful in the world or in art, in fiction or real life; an exalted moral strength and purity; a glowing imagination which soars into the seventh heavens; an insight and a keenness of external observation which make the atom as grand to him as a planet; a depth of reverence which exalts him while he abases himself."

CORRESPONDENCE.

ABOUT ANTS.

Messrs. Editors.

ABOUT four years ago a large, wholesale-grocery firm, doing business on Strand Street, in this city, received a consignment of several barrels of *onions*. These onions were raised by a German farmer living in one of the counties lying west of the Colorado River, and near the line of the railroad running between Galveston and San Antonio. The onions were grown in a black, sticky soil, as shown by the large quantity adhering to them. In some of the barrels there were a great number of small *black* ants, which were evidently brought here with the onions from the same place. This particular species of ant was unknown here before. The Island of Galveston is mostly sandy, and the ants heretofore observed here were of light color. These imported colonies have increased enormously, until there is not a counting-room on Strand Street that is not literally *infested* with them. I am no entomologist, but it seems to me they exhibit some peculiarities that would greatly interest Sir John Lubbock. They do not appear to be very troublesome to the grocerymen—not attacking sugar, cheese, etc., which other small ants delight in—but, like a great many people, they show the most decided fondness for *printer's ink* on a newly-printed newspaper. If the morning paper is laid down in the counting room on a chair, table, or desk, in a few moments it will be covered by countless thousands of these lively little pests. They seem to extract something from the ink on the paper of which they are excessively fond. The paper itself they do not injure, and it is only a freshly-printed paper that attracts them. They are very active in their pursuit of fresh newspapers, the moment one is thrown down being the signal for hosts of them to rush from the floors and walls to cover it. They do not seem inclined to be quarrelsome with themselves or their "two-footed rivals," unless disturbed in their favorite pastime, by having the morning paper taken away from them, when, in attempting to shake them off, they frequently inflict some punishment on the hands, thus showing that they are not without the means of defensive and offensive warfare. The book-keepers and clerks have discovered that a *broad chalk-line* drawn around the desk-legs, and repeated daily, will offer an effectual barrier to their ascent of the desk. This is the only preventive yet discovered.

One remarkable fact I desire to call attention to is this: While they have no fondness for the common black writing-ink that does not copy, they are exceedingly fond of a variety of *copying* writing-ink—such as I am using in this letter—made in Paris, and called "Encre violette noire communicative." When the legs of my desk have not been properly *chalked*, and I am writing letters to correspondents, these little pests will cover my paper, run over the fresh writing, and frequently drag the ink on their legs, "making some marks" of their own. (You can see the peculiar chirography of one of my little friends on the first page of this letter.) Sometimes one or more will run up the pen-point as it is moving over the paper, and then occurs a very singular phenomenon indeed: The movement of the pen seems to enrage it, and it immediately plunges its forceps into the thick ink, when at once the ink, which was a dark-violet color, changes to a bright *litmus* color, and seems to have acquired the property of "*striking through*" the paper, no matter if of extra thickness. This change of color I attribute to the *formic* acid the insect discharges into the ink in its rage. In about five minutes the writing changes to a dark-violet again, due, I suppose, either to the absorption of oxygen, the evaporation of the formic acid, or some other chemical change. I may send you some more items of interest about these little pests, but in the mean time I would be glad to know how to be rid of them entirely.

Very respectfully yours,

L. C. FISHER.

GALVESTON, TEXAS, *October* 11, 1880.

A BRILLIANT METEOR.

Messrs. Editors.

ON the evening of Wednesday, the 9th instant, I observed a very brilliant meteor, which made its appearance in the southwest, at an elevation of about forty degrees above the horizon. Its rate of motion was very slow, and it was visible fully three quarters of a minute. A long bright line was left in its path, and this remained visible from 5.27 o'clock, when I first observed the meteor, until 5.45 o'clock. This streak seemed to be composed of luminous vapor. About five minutes after its appearance, the line took a zigzag form and resembled a "streak" of lightning. Its form was

constantly changing until it disappeared in the approaching darkness. I have never before observed a meteor whose "tail" remained visible so long. The appearance of this meteor created great consternation among the negroes, and many of them imagined that the "last day" had arrived. Nothing has ever been seen to equal it by any one in this neighborhood.

Yours respectfully,

JOHN HAWKINS.

PROSPERITY, S. C., *December* 10, 1880.

EDITOR'S TABLE.

EVOLUTION AND ORIGINALITY IN ART.

WHEN we compare pictures of the sixteenth and of the nineteenth centuries at the Metropolitan Museum of Art, New York, we are conscious that the charm of modern work is in the truthful delineation of scenery and character, in a certain reflection of our experiences, and in fitness as related to the drift of our imagination. We see a reality and daylight effect which we miss in allegorical and other subjects by artists of the fifteenth and sixteenth centuries. The coloring in pictures by Rubens and Murillo may be impressive, but not even this can obscure the truth that the result is not suited to the modern eye and taste. Most of us prefer nature mirrored by some of our modern masters. In fact, the disposition to appreciate work that seems practical does not favor the introduction of ancient methods. The pursuit of a highly developed sense of humor must impress artists with the importance of close attention to propriety and probability in every design. The fact that ancient art is not suited to present standards of taste was hinted at by Thackeray in "The Newcomes," in the artist who painted immense figures, and whose ideas of art were expressed in a picture fourteen feet high. The novelist intimates that this was high art in a literal sense; but the principal force of his satire is shown in the following remarks from the artist: "The models of the hancient Britons in that pictur' alone cost me thirty pound. . . . You recognize Boadishia, colonel, with the Roman 'elmet, cuirass, and javeling of the period—all studied from the hantique, sir, the glorious hantique."

We also find a ludicrous contrast when ancient art is subjected to the practical test of modern scientific criticism, as seen in the disregard of the laws of equilibrium when angels are represented with arms as well as wings.*

The phrase "school of art" seems objectionable when it means more than a preparatory course by which the rudiments are mastered. An artist ought to be independent of all schools, or have a touch of all in his work, because otherwise his liberty will be restricted.

The advantage of originality appears in strong relief when we examine the negative work of imitators. While it is seen that artists having genius can produce striking effects, using apparently commonplace subjects, it is yet clear that imitators can not produce the same effects, because they fail to see them in nature. The picture painted by a great artist and the original in nature always produce two distinct and very different impressions upon the observer. Owing to some subtile change, which it is impossible for an imitator to follow, the picture has an indefinable effect of which we are not conscious in the natural occurrence or object. For this reason the imitators of original work must always fail. They see the effect after it has been rendered, but they can not perceive similar effects in the outer world of nature, as distinguished from the

* See "Popular Science Monthly," April, 1879: "The Monstrous in Art," by Samuel Kneeland, M.D.

inner world of constructive thought. The striking peculiarity of the work causes them to overlook the delicate and truthful touches by which the general harmony and fitness are maintained. The unprecedented qualities in a work of genius are always sustained by a certain truth to nature.

Originality generally causes severe criticism from contemporary artists, because its tendency is to displace or weaken the established standards. In fact, the opposition usually becomes so intense that the merit of the old method is overlooked on one side, and the great value of a new insight is overlooked on the other. Conservative critics have very often tried to check venturesome innovators by misusing the word mannerism, which does not properly apply to peculiar work. The word means tasteless uniformity. This can be fairly maintained in opposition to critics who think that any incessantly-recurring effect, even though original and striking, is mannerism. Such critical objections ought not to influence an artist to abandon a forcible system of treatment, because the danger of anything really powerful dwindling into a series of tedious repetitions is very slight.

Where there is merit there is continuous growth, whereby the strong current of individuality or sameness of treatment is accompanied by constant transformations, absorbing new material, and finding new methods of expression.

It seems obvious that, after suitable instruction, during which any school may have sway, the artist must look for natural effects in the world directly around him, and not in Rome or in Paris. Nor should he use the special colors or tones advocated by conformists. Objects appear to him of a certain hue, or a certain action of the human figure appears worth rendering. Let him delineate these as he sees them, and be not discouraged by many failures and defects. His strong point may be discerned by close attention to his natural tendencies. In this way the true representation of his impressions will make others conscious of something which before lacked emphasis. Such development of originality in art, accompanied by hard and conscientious labor, may result in works of great fame, and in the evolution of art to a higher grade of adaptation to nature. In the future, the artist may better express ideal conceptions, because a wider mastery of facts and subjects involves increased power and skill.

LITERARY NOTICES.

INTERNATIONAL SCIENTIFIC SERIES, NO. XXX.

ANIMAL LIFE AS AFFECTED BY THE NATURAL CONDITIONS OF EXISTENCE. By CARL SEMPER, Professor of the University of Würtzburg. With Two Maps and One Hundred and Six Woodcuts. New York: D. Appleton & Co. Pp. 472

WE have here a volume that will raise still further the already high character of the series to which it belongs. It is a fresh and original contribution to a most interesting branch of zoölogy, which will be indispensable to every naturalist, and will be prized by all readers who care for the progress of knowledge concerning the general phenomena of life. Professor Semper is a leading German biölogist, and, being a master of English, he was invited to come to Boston and give a course of twelve lectures before the Lowell Institute. He availed himself of the occasion to bring forward, in a form as popular as the nature of the materials allows, the results of his studies in a special province, zoölogical science.

The author is, of course, an evolutionist, and recognizes that Darwin's views have revolutionized biological method. But he thinks one of the results has been to give too great an impulse to speculation. He says that enough has been done by Darwinists in the way of philosophizing, and that the task now before us is to apply the test of exact investigation to the hypotheses

laid down. It is infinitely easy to form a fanciful idea as to how this or that fact may be hypothetically explained, and very little trouble is needed to imagine some process by which hypothetical fundamental causes, equally fanciful, may have led to the result which has been actually observed. But, when we try to prove by experiment that this imaginary process of development is indeed the true and inevitable one, much time and laborious research are indispensable. We have here the clew to Semper's position as a biologist. He thinks that the school of speculative system-makers, represented by Haeckel, are given to an over-indulgence in hypotheses, and might better concentrate their efforts upon the work of observation and experiment, and the more rigorous investigation of facts.

Of the problems brought into prominence by the doctrine of evolution, none is more fundamental than that of variability in animal organisms. It has, of course, long been known that animals possess this property, but the critical and unsettled question is, To what extent and under what conditions is it manifested? Variability is probably that trait of animate beings which may be first and most easily traced by exact investigation, both to its limits and to its efficient causes. There is, however, at present much strife of opinion upon the subject, and this can be only harmonized by closer research. The present volume is devoted to this inquiry. It is a study in organic variation, and the author aims to present the general facts and hypotheses, which are either of universal significance or offer favorable subjects for experimental treatment.

But it is desirable to still further illustrate the specialty of Dr. Semper's work. The general science of zoölogy has two great branches, morphology and physiology, which, although closely connected, are yet so widely different, both as to their details and to the paths they have struck out for solving their respective problems, that it becomes necessary to keep them separate as two independent divisions of science. Morphology, or the science of form and structure, aims to discover those affinities of relationship in animals which actually exist, and to found on them a natural system of the animal kingdom. It is a statical inquiry—that is, it delineates the conditions and relationships of organic structures, their differences and similarities, simply as existing facts, with no necessary reference to the manner in which they have been produced. Were all life suddenly destroyed upon the earth, and nothing left but dead organisms capable of dissection, there would still remain the material for morphological study.

Physiology, on the other hand, deals with the dynamics of life. It investigates the functions or activities of living parts, and elucidates the forces, causes, and conditions that have produced existing forms. Physiology explains what morphology describes; and, in this large sense, it is the task of physiology to give account of the facts which morphology embraces in its natural system.

But, from this point of view, physiology itself has two broad divisions. Simple physiology, as it is usually known, treats of the activities or the functions of the organs, such as the brain, stomach, heart, muscles, spinal cord, lungs, kidneys, etc., which may be considered as carrying on independent processes, or in their vitally coördinated, intimate, mutual relations. But, in contradistinction to this conception of the physiology of organs, there is also a more comprehensive physiology of animal organisms, which may be properly termed universal physiology. It treats of the general causes, conditions, and laws of the development of organisms, and of the transmutation of one form into others. Here we meet the question of the relation of organisms to their environing conditions, and of animals as acted upon and modified by the external forces of nature. The problem of the geographical distribution of animals, of their extension into new habitats, of their extermination, the acquirement of divergent traits and new qualities, and of the origin of species, is here presented. We have a new order of dependences, analogous to the mutual dependence of organs in common physiology, but it is now a dependence upon the conditions of external nature. Professor Semper says: "If the American prairies were to cease to produce grass, the first result would be the rapid and utter extinction of the now numerous herds of buffaloes, and

on their existence depends that of the surviving remnant of the ancient Indian population of America. If the various insectivorous birds of North America were exterminated, within a very few years, beyond a doubt, all the produce of the rich agricultural districts of that continent would be destroyed. If we change the mode of life of any single animal, the change will instantly have an influence on all the other animals whose healthy existence was in any way dependent on its normal functions before it was altered. Although it is certainly true that the various animals inhabiting a country are not so intimately interdependent as the organs of the individual, the relations in the two cases may be very directly compared. The normal numerical proportion, mode of life, and distribution of animals would be altered or destroyed by the extermination of one single animal, just as the whole body suffers, with all its organs, if only one of them is destroyed or injured. And, in both cases, Nature has analogous remedies at her command. In the one case, the function of the incapacitated organ can be assumed, at any rate to a certain extent, by some other uninjured organ, exactly as, in the other case, the function of the exterminated animal may be fulfilled, with regard to the whole fauna of the country, by some other animal. But a perfect compensation for the loss sustained is impossible in either case."

In further illustration of this idea, Professor Semper says: "The fauna of a district thus takes the aspect of a vast organism whose separate members—the different species of animals—are living parts of the body, and which has had too its embryology—i. e., its development in time. These species as regards the laws of their local distribution may be regarded *morphologically* as the limbs of a gigantic organism which throws one or other of them up into the air on the top of some mountain-peak, while others are flung into ocean-depths, subterranean caves, lakes, or rivers. But they may also be studied *physiologically*, and compared to organs which by their functions and importance influence the life of the whole mass, and are interdependent by the most various physiological relations like the organs of a healthy living body." The nature of the task undertaken by the author is still further exemplified in the following passages:

Before going on to the particular inquiry, it seems desirable that the expression "external conditions of existence" should be as accurately defined as may be. I have already said that I wish to see as wide an application given to it as possible, so as to include every influence, however insignificant and difficult to detect, that can affect the "fitness for survival" of a species, and to investigate its mode of action. This explanation might suffice, but I prefer to illustrate my meaning by a few further considerations.

Everything which tends to hinder or to favor the continuance of the life of the individual and the propagation of the species, as such, must be regarded as a condition of existence for that species. In this sense every organism existing on the face of the globe, as well as every inorganic constituent of the earth's surface and of the atmosphere, is a condition of existence for all animals. Their relations to those organic and inorganic elements differ only in degree, in being more or less remote. Heat or cold, light as well as nourishment, the density of the atmosphere, the water or the soil in or on which animals pass their lives, electricity, and the chemical constituents of the media surrounding them, whether air or water, the plants or other animals with which they live, either in the closest connection or in mere association—everything, in short—may and must exercise a certain influence on animals, and may be harmful or prejudicial to them; and there is nothing on the face of the earth that may not be regarded as an essential condition of existence to some species of animal. It is self-evident that the influences of these manifold conditions must be in the highest degree various. One animal requires a high temperature in order to live, another a low one; one form prefers a very damp atmosphere, another a dry one; many are destined to live always under water or in the soil, while quite as many disport themselves in the freer medium of the air. If we could suddenly reverse all the conditions of existence which are indicated by these modes of life, we should annihilate all the animal life on the earth; for no fish can swim in the air, no bird can live permanently under water, a mole can not climb, a salamander can not exist in a desert, nor a desert-snail in the virgin forests of the tropics. If, on the contrary, we reverse the conditions slowly, but still at a perceptible rate, it is probable that most animals would perish while a few would survive. But, if we suppose that such changes—in the atmosphere, for instance, in the constituents of water or of the soil, etc.—were effected so slowly as to be perfectly inappreciable by man, it is highly probable that the number of surviving forms would be very considerable. The influence of the conditions of existence thus changed is sometimes very different on nearly allied forms; for instance, one species of *Neritina* can live equally well in fresh, brackish, and sea water, while others

occur only in one or the other, and can not survive any diminution or increase of the saltness of the water they live in. The simple reason of this phenomenon is the fact that the life of an animal depends not merely on the influence of the external conditions, but on the reaction of its own organization. If we transfer a stickleback directly from fresh to salt water, and leave it there for days or weeks, it will not perish if it be supplied with sufficient food. But, if at the same time we place one of the common fresh-water mussels in sea-water, it will soon die, sometimes in a few hours. The remarkable difference in the behavior of these two creatures is easily explained by the following hypothesis: In both animals the salt water is transmitted through the skin to the tissues of the body; but this takes place to a much greater extent in the mussel than in the fish, and thus injures it, while the fish can bear the same quantity of salt it has absorbed. If our migratory fishes, as the salmon, had as great an affinity for the salt of the sea-water as the mussels have, they would soon cease to exist, or would have to become adapted to live wholly in fresh water. Thus every change in the conditions of existence influences different animals in different ways. The problem, then, is to investigate more accurately these different effects of changed conditions.

Professor Semper's twelve lectures before the Lowell Institute form the twelve chapters of his book. The considerations here presented are put forward in the first or introductory chapter, in which he defines his point of view, and the plan of the discussion. The work is divided into two parts, the first being devoted to "The Influence of Inanimate Surroundings," and the second to "The Influence of Living Surroundings." Chapter II takes up "The Influence of Food"; III, "The Influence of Light"; IV, "The Influence of Temperature"; V, "The Influence of Stagnant Water"; VI, "The Influence of Still Atmosphere"; VII and VIII, "The Influence of Water in Motion"; IX, "Currents as a means of extending or hindering the Distribution of Species"; X, "A Few Remarks on the Influence of Other Conditions of Existence"; XI, "The Transforming Influence of Living Organisms on Animals"; XII, "The Selective Influence of Living Organisms on Animals." Appended to the volume are sixty pages of valuable notes, followed by a copious alphabetical index.

ANNUAL REPORT OF THE CHIEF OF ENGINEERS, UNITED STATES ARMY. Pp. 264.

THE report describes what was done during the year ending June 30, 1880, and what was needed to be done for the seacoast and lake frontier defenses of the country, and for the improvement of the rivers and harbors of the whole country; and records the progress of the special work and of the surveys assigned to the corps of engineers. Several maps of Pacific States and of the survey of the Mississippi River, and lake charts, have been published, and an outline map of the territory west of the Mississippi River, on a scale of $\frac{1}{2000000}$, is in preparation.

LIFE AND HER CHILDREN; GLIMPSES OF ANIMAL LIFE FROM THE AMŒBA TO THE INSECTS. By ARABELLA B. BUCKLEY. New York: D. Appleton & Co. 1880. Price, $1.50.

AFTER light came life, and with that life there came its two great functions—growth and development. With the simplest as with the most complex forms there is the same eager race to be run, to increase in size, to multiply, and, thus replenishing this earth, to die. "Life and her Children" is a praiseworthy and admirable attempt to tell us something of the Children that Life sends forth, and of their history. Its main object is to acquaint young people with the structure and habits of the lower forms of life; but in our deliberate judgment it will do a great deal more. None will read its introductory chapter without advantage, and few will read the volume through without enjoyment. Within its narrow limits of three hundred small pages no candid reader would expect to find all the details that might be wished for, or all the illustrations that might be desired. What constitutes the book's chief charm is the marvelously simple yet quite scientific style which runs through it, the food for thought and future study which it affords, and the truly philosophic glow which lights up its every page. The volume gives a general account of Life's Simplest Children, the Protozoa. The word "slime" does not seem to us quite a happy term by which to designate the living protoplasm of these creatures; this word conveys the idea of a something adhesive or glutinous, or of a something thrown off a living organism—a something without a structure (sordies, eluvies)—and there seems somewhat of a "contempt for nature," a thought certainly never present in the au-

thor's mind, in the use of such a word. Jelly would seem a more appropriate word, as conveying the idea of the consistency requisite for life, and would have the sanction of use. Thus the Noctilucæ, called in this volume "tiny bags of slime," were described, if we mistake not, by their discoverer as "tiny spherical gelatinous bodies," and Professor Huxley says, "Noctiluca may be described as 'a gelatinous transparent body about the one sixtieth of an inch in diameter.'"

The chapter on "How Starfish walk and Sea-Urchins grow" is excellent. The story of how the five curious little oval jelly bodies, swimming about by their jelly lashes in the depths of the smooth water in some English bay ended in becoming respectively a lily-star, a brittle-star, a starfish, a sea-urchin, and a sea-cucumber, is well told, and woodcuts, though they make one see as in a glass darkly, help in their own way to make the meaning plain. In the "Outcasts of Animal Life" a difficult problem is treated of. It need not surprise one that it is not solved. The last four chapters tell of "the Snare-Weavers and their Hunting Relations (spiders)"; the insects which change their coats but not their bodies, and those which remodel their bodies within cover of their coats; "the Intelligent Insects with Helpless Children, as illustrated by the Ants." This volume thus tells of the greater part of the living invertebrate animals as they are spread over the earth to fight the battle of life. "Though in many places the battle is fierce and each one must fight remorselessly for himself and his little ones, yet the struggle consists chiefly in all the members of the various brigades doing their work in life to the best of their power, so that all while they live may lead a healthy, active existence. The little bird is fighting his battle when he builds his nest and seeks food for his mate and his little ones; and though in doing this he must kill the worm, and may perhaps by and by fall a victim himself to the hungry hawk, yet the worm heeds nothing of its danger till its life comes to an end; and the bird trills his merry song after his breakfast, and enjoys his life without thinking of perils to come. So Life sends her Children forth; and it remains for us to learn something of their history. If we could but know it all, and the thousands of different ways in which the beings around us struggle and live, we should be overwhelmed with wonder. Even as it is, we may perhaps hope to gain such a glimpse of the labors of this great multitude as may lead us to wish to fight our own battle bravely and to work and strive and bear patiently, if only that we may be worthy to stand at the head of the vast family of Life's Children."

The work forms a charming introduction to the study of zoölogy—the science of living things—which we trust will find its way into many hands.—*Nature.*

TRANSCENDENTAL PHYSICS: An Account of Experimental Investigations from the Scientific Treatises of JOHANN CARL FRIEDRICH ZÖLLNER, Professor of Physical Astronomy at the University of Leipsic. Translated from the German, with a Preface and Appendices, by CHARLES CARLETON MASSEY. With Illustrations. Boston: Colby & Rich. Pp. 217. Price, $1.50.

THERE was considerable excitement a year or two since over the spiritualistic demonstrations at Leipsic, Germany, in which the professors took up the claims of Henry Slade, the eminent American "medium." Zöllner was prominent in the inquiry, and published his results, which arrested attention chiefly from the novelty of some of the doctrines which he connected with the experiments. He published a book of views and results under the title of "Transcendental Physics," which was the third volume of a course of scientific criticism. The substance of that work is reproduced in the present translation, together with numerous well-executed illustrations of the appliances used and the operations performed.

The book is a contribution to spiritualism, and treats of a portion of the experiences of Mr. Slade in his great mission over the world to establish, by slate-manipulations, etc., the immortality of the human soul. Poor old senile Dr. Hare, when captured by the Philadelphia spiritualist several years ago, undertook to prove that the soul is immortal by inventing a wooden spiritoscope for public exhibitions. Believing that this great question has been left in

doubt quite long enough, our enterprising spiritualistic friends have decided that it must be solved. And as speculation seems to have failed to settle it satisfactorily, they are bound to do it in the clearest and completest possible manner by experiment, so that the conclusion shall have the same validity that is conceded to strict scientific investigations. It would seem that Professor Zöllner had got tired of being shut into the common field of natural law as a theatre of research, and was determined to break out and get into a larger and more promising field. Hence he properly terms his new results "Transcendental Physics," that is, physics beyond the sphere of the senses. We doubt if the time has quite come for so ambitious an adventure. Old-fashioned physics is still in its infancy, though its growth is vigorous, its accomplishments already vast, and its legitimate promises boundless. After thousands of years of groping to find the true method of arriving at the truth of nature, that method has at last been found and abundantly verified as opening the right path of future inquiry. Yet the method has been really but just mastered, and we think it would be wise if our physicists could content themselves to pursue it humbly and faithfully for—say the next thousand years. Nor does Professor Zöllner's experience encourage us in the least to qualify this recommendation; for it looks as if he had not yet served half his apprenticeship to the existing and well-attested method. The proneness to indulge in wayward fancies, in groundless conjectures, in imaginary explanations and insane speculations, has always been the great obstacle to sober and cautious science, and we think it is the great office of science to discipline and subdue this tendency. But Professor Zöllner has hardly yet learned the rudiments of his scientific lesson. Nature, as disclosed to the common intellect of man, is not sufficient for him. He scorns its limitations, and is bound to know what is outside. So at the very opening of his book he makes a grand transcendental somersault, and comes down—Heaven save us!—in the fourth dimension of space. Zöllner is free, but we poor worms of the dust can not follow him. We have all we can possibly do in three dimensions of space, and it will be a considerable period before this is exhausted. Let those who are inclined buy the "Transcendental Physics," and follow its author if they can. Yankee enterprise is proverbial, and there will no doubt be many who hold to the inspiring motto of the daring Sam Patch, that "some things can be done as well as others."

CONSUMPTION, AND HOW TO PREVENT IT. By THOMAS J. MAYS, M.D. New York: G. P. Putnam's Sons. 1879. Pp. 89. Price, $1.

THIS little monograph is aimed at the prevention of the most destructive of all diseases. It offers an explanation of the nature of consumption, and then takes up the various hygienic agencies which are potent to protect the system from its invasion. The author epitomizes his book as follows: "In summing up the considerations in the preceding pages, I think it appears conclusive that consumption, or the tendency to it which exists in many individuals, is essentially a premature dissipation of the force and matter of the body, and that improper food, bad air, deprivation of sunlight, poor clothing, want of physical exercise, disease, imperfect digestion, all accelerate this process of waste. Therefore, in all our efforts at prevention, the path of duty lies straight before us, and consists in conserving these two elements of the body by laying a good foundation in infancy, by preserving the organs of digestion, by eating an abundance of rich and nutritious food, such as fat, butter, meat, milk, eggs, etc., by breathing pure air, by living on dry soil, by wearing warm and comfortable clothing, by taking plenty of physical exercise, and by avoiding disease and injurious occupation."

BRITISH THOUGHT AND THINKERS: INTRODUCTORY STUDIES, CRITICAL, BIOGRAPHICAL, AND PHILOSOPHICAL. By GEORGE S. MORRIS, A. M., Lecturer on Philosophy in the Johns Hopkins University. Chicago: S. C. Griggs & Co. Pp. 388. Price, $1.75.

THIS volume is founded on some lectures lately delivered before a mixed audience of ladies and gentlemen at the Johns Hopkins University, Baltimore. It professes to be introductory rather than exhaustive—an invitation to reflective and systematic

study rather than a substitute for it. There is a considerable biographical element in the treatment, and the author's aim seems to be to elaborate "correct views concerning the essential nature and value of the most conspicuous current of abstract thought in the English language." The author is a metaphysician and an ontologist, and, in so far as his work is doctrinal, it is a dry agnosticism. He does not believe that knowledge is bounded by phenomenal relations, and spurns the idea that any amount of generalized truth derived from the sciences can form a system of philosophy properly so called; but, independent of its speculation, there is much instruction to be gained from his work.

ELEMENTARY PROJECTION-DRAWING. By D. EDWARD WARREN, C. E. New York: John Wiley & Sons. 1880. Pp. 162. Price, $1.50.

PRACTICAL PLANE GEOMETRY AND PROJECTION. 2 vols. By HENRY ANGEL. New York: G. P. Putnam's Sons. 1880. Price, $3.50.

THE first of these text-books is the well-known manual of Professor Warren, which has now reached a fifth edition. It has undergone a thorough revision, and some parts of it have been rewritten, while it has been made more complete by the addition of a division devoted to a consideration of the elements of machines.

The work of Professor Angel is one in the "Advanced Science Series" of the publisher, and forms a continuation of the more elementary one of the author in the same series. The chapters upon projection are prefaced by several upon plane geometry, while the main subject is fully presented and illustrated by numerous examples and problems. A volume of finely executed plates accompanies the text.

The subject of projection-drawing, besides being of large educational value, is also of great practical importance. It is concerned with representing upon a plane surface solid objects in such a way as to show their real dimensions, and is, therefore, a necessary preparation for the artisan who has to construct work from drawings of this kind. It is also of value to all those who desire to know how to represent their ideas of any construction, so that they will be understood by mechanics. Any one desiring to pursue the study will find in either of these works all that he needs to a thorough comprehension of it.

THE PUBLISHERS' TRADE-LIST ANNUAL, 1880. Eighth Year. New York: F. Leypoldt. Price, $1.50.

THIS massive volume embraces the latest catalogues of their books supplied by the publishers, preceded by an order list including all books issued from January to August, inclusive, by the publishers represented in the annual; a classified summary and alphabetical reference list of books recorded in the "Publishers' Weekly" from July 1, 1879, to June 30, 1880, with additional titles, corrections, changes of price and publisher, etc. (forming a provisional supplement to the American Catalogue); and the American Educational Catalogue for 1880. The work, the materials of which are received directly from the publishers themselves, gives the complete literary history of the year in the United States, and is indispensable to the book-buyer.

THE GEOLOGY OF HUDSON COUNTY, NEW JERSEY. By ISRAEL C. RUSSELL. (From the Annals of the New York Academy of Sciences.) Pp. 80, with Two Plates.

THE geology of this county, which is immediately opposite the lower part of New York City, presents many interesting features, the most prominent of which is the great ridge of trap-rock, forming the southern end of the Palisades, which traverses it from north to south. It is nearly perpendicular on the eastern edge, but slopes back gently toward the west. Beds of triassic sandstone, slate, and shale lie on either side of it. Archæan rocks—gneiss in a part of Jersey City, serpentine at Castle Point, Hoboken—are found within its borders. The top of the trap ridge bears marks of the action of the great glacier, whose moraine is found on Long and Staten Islands and in the "Short Hills" of Plainfield. On the surface are sand-dunes along the Newark meadows and Newark Bay, and on Bergen Neck, and the swamp deposits of the salt meadows, still in process of accumulation. The details of these features, their relations to each other, and their economical and sanitary aspects, are clearly described in the essay.

AN ELEMENTARY COURSE OF GEOMETRICAL DRAWING: Containing Problems on the Right Line and Circle, Conic Sections and other Curves; the Projection Section and Intersection of Solids; the Development of Surfaces and Isometric Perspective. By GEORGE L. VOSE, A. M., Professor of Civil Engineering in Bowdoin College. Illustrated by Thirty-eight Plates. Boston: Lee & Shepard.

THIS seems to be an excellent introduction to the practice of geometrical drawing. Its method has been used for several years in classes with the most favorable results. It was prepared for the use of the lower classes in engineering schools, but parts of it may no doubt be made excellent use of in the high schools. The author claims that it is well adapted for those who desire to pursue this branch of study by themselves and without a teacher. But he strongly recommends pupils to commence with a master wherever practicable, as they will thus save time, and avoid the formation of bad habits, so easy to get and so hard to lose.

AMONG MACHINES. A Description of Various Mechanical Appliances used in the Manufacture of Wood, Metal, and Other Substances. A Book for Boys. Copiously illustrated by the author of "The Young Mechanic." New York: G. P. Putnam's Sons. Pp. 335. Price, $1.75.

ON the extensive subject of machinery, which would fill cyclopædias, this volume takes up only such parts as are assumed to have a general interest, and concerning which it is well that all active-minded boys should be instructed. It treats of those fundamental laws which underlie the system of machinery, and upon which are founded the various mechanical combinations which have contributed so much to the development of manufactures. The need of understanding these principles would be apparent, and we remember that hand processes are rapidly disappearing by the substitution of machinery, so that the mechanic who has been trained to a special manipulation hardly knows at what moment an unexpected invention may undermine and destroy his vocation. Each new victory and invention is, moreover, but a step toward others, and we are every day surprised to observe how triumphant ingenuity has overcome difficulties hitherto supposed to be insurmountable, and which makes an inroad upon the traditional handicraft labor, and cheapens a product of general utility. The author of this book, therefore, thinks it a fit time to instruct the younger portion of the community in the details of the more ordinary machines with which they may perhaps some day become closely and personally interested. Twenty chapters are devoted to the most important machines, processes, and mechanical arrangements in the wide field of manufacturing industry.

TELEGRAPHIC DETERMINATION OF LONGITUDES ON THE EAST COAST OF SOUTH AMERICA. By Lieutenant-Commanders F. M. GREEN, C. H. DAVIS, and Lieutenant J. A. NORRIS, U. S. N., in 1878 and 1879. Published by order of Commodore William D. Whiting, U. S. N., Chief of the Bureau of Navigation, Navy Department. Washington: Government Printing-Office. Pp. 87.

THE longitude of points on the east coast of South America has been very uncertain until recently, for the results obtained by apparently trustworthy methods have differed by almost incredibly large quantities. The extension of telegraphic cables gave the opportunity to make more accurate determinations from some well-determined point in Europe by way of Madeira and the Cape Verd Islands with the eastern South American coast. The connection was made from Land's End by Carcavellos, at the mouth of the Tagus, and the Brazilian submarine telegraph. The determinations made by the commission, combined with the determinations of meridian distances made by Professor Gould at Cordova, furnish a valuable system of longitudes embracing about twenty stations in the interior. A curious fact connected with this work is, that it has given the first correct determination of the longitude of Lisbon.

THE RELATIONS OF SCIENCE TO MODERN LIFE. A Lecture delivered before the New York Academy of Sciences. By HENRY C. POTTER, D. D. Published by the Academy. New York: G. P. Putnam's Sons. Pp. 29.

THE author presents, in the easy, flowing style of a popular lecture, a view of the obligations we are under to science in the commoner features of our domestic and social life.

LEARNING TO DRAW; OR, THE STORY OF A YOUNG DESIGNER. By VIOLLET-LE-DUC. Translated from the French by Virginia Champion. Illustrated by the Author. New York: G. P. Putnam's Sons. Pp. 324.

THIS work was the last written by the illustrious French author who has done so much to rationalize art education. His method of instruction was logical, beginning always with the simplest elements and proceeding slowly to more complex considerations, while the progress at every step is made pleasant and attractive. Le-Duc was always suggestive, and, instead of grinding students through a hard didactic course, he ever aims, by showing the connection between one study and another, to make the work intellectually attractive. All special results must have the broadest possible foundation. And in every way the student is inspired with a love of excellence and an ambition to attain the highest standard and accomplish the most thorough work. Of the value of the author's method the translator thus speaks: "Teachers of art, both general and technical, and, for that matter, teachers of any subject, will find this volume of Viollet-le-Duc of no little service in suggesting methods of instruction. It shows how students, young or old, are to be interested; how all the surroundings of daily life contain suggestions for the most interesting and important lines of investigation; how students are to be taught to think out processes for themselves, and to develop their powers of comparison and reasoning; how the study of art of necessity leads us back to the study of nature, which underlies all art; and how, as before said, the basis of all education must be perception, so that learning to draw well and learning to do anything properly depend upon first learning to see correctly."

A TEXT-BOOK OF ELEMENTARY MECHANICS. By EDWARD S. DANA. New York: John Wiley & Sons. 1881. Pp. 291. Price, $1.50.

PROFESSOR DANA has aimed in this work to present the subject of mechanics clearly and concisely, and develop its fundamental principles in their logical order. The book is restricted to the mechanics of solids, which is considered under the general heads of kinematics, dynamics, and statics. Numerous problems, involving the principles elucidated in the various sections, are furnished for the pupil to work upon, answers to which are given at the close of the book. We can discover no reason why this latter feature should have been added, and think the space might have been much better devoted to additional problems.

SUMMARY OF SUBSTANTIALISM; OR, PHILOSOPHY OF KNOWLEDGE. By JEAN STORY. With Additional Illustrations. Boston: Franklin Press; Rand, Avery & Co. Pp. 113. Price, 35 cents.

THE author starts with the assumption that all authority, "so called," not founded on what nature teaches through facts actually demonstrable or knowable through analogy, should be rejected. Nevertheless, he believes that the theory that what is non-objective to the senses is immaterial and unknowable is erroneous and deleterious, as is also the theory that knowledge is, either directly or indirectly, miraculously revealed. In harmony with these doctrines, he endeavors to build up a new philosophy of the human organism. The present essay appears to be introductory to a larger work on the same subject.

THE FEELING OF EFFORT. By WILLIAM JAMES, M. D., Assistant Professor of Physiology in Harvard University. (Anniversary Memoirs of the Boston Society of Natural History.) Boston: Published by the Society. Pp. 32.

THE author's purpose is to offer a scheme of the physiology and psychology of volition, to inquire of what nervous processes the feelings of active energy are concomitants. He first considers muscular exertion as an afferent feeling, then examines into the power of the will over exertion, analyzing the cases of acts in which no effort of either is required, in which the stress of effort is laid on the exertion while the will is lightly taxed, on the will when the muscular exertion required is insignificant, and cases in which the will effort operates in all its vigor while the muscular function is not regarded. Lastly, he considers the question of a dynamic connection between the inner and outer worlds, answering it in the negative.

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Address in Medical Jurisprudence, Psychology, State Medicine, etc. By James F. Hibberd, M. D. Philadelphia. 1880. Pp. 17.

On the Action of Carbolic Acid upon Ciliated Cells and White-Blood Cells. By T. Mitchell Prudden, M. D. January, 1881. Pp. 17.

How to Live in Winter. By Amelia Lewis. New York: Food and Health Publishing Office. 1881. Pp. 84. 25 cents.

"The Chrysanthemum: A Monthly Magazine for Japan and the Far East." Yokohama: Kelley & Co. Vol. I, No. 1. January, 1881. Pp. 36. 25 cents each, or $2 a year.

"Quaker City Gazette: A Weekly Periodical devoted to Science, Literature, and Art." E. Ellsworth Wensley, Editor. Philadelphia: Quaker City Publishing Co. Vol. I, No. 1. January, 1881. Pp. 16. $2 a year.

"The Illustrated Cosmos." Issued Monthly. Everett W. Fish, General Editor. Chicago. Vol. I, No. 1. January, 1881. Pp. 16. 15 cents a copy, $1.50 a year.

Principal Characters of American Jurassic Dinosaurs. By Professor O. C. Marsh. Part IV. Spinal Cord, Pelvis, and Limbs of Stegosaurus, with Three Plates. February, 1881.

On the Microscopic Crystals contained in Plants. By W. K. Higby. Pp. 18.

Annual Report of the California State Mineralogist, from June to December, 1880. Sacramento. 1880. Pp. 43.

"The Floral World: A Monthly Journal devoted to Floriculture, Horticulture, etc." D. R. Woods, Editor. New Brighton, Pennsylvania. Vol. I, No. 1. January, 1881. Pp. 24. $1 a year.

"The Religious Evolutionist: A Monthly Magazine devoted to a Scientific and Practical Religion." S. W. Davis, Editor. Topeka, Kansas. Vol. I, No. 1. January, 1881. Pp. 28. $1.00 a year.

Circulars of Information of the Bureau of Education. No. 4, Rural School Architecture. Illustrated. No. 5, English Rural Schools. Washington: Government Printing-Office. 1880.

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POPULAR MISCELLANY.

Bone-Caves in Pennsylvania.—Professor Leidy in company with Dr. T. C. Porter, of Easton, Pennsylvania, visited, in August last, Hartman's Cave, near Stroudsburg, Pennsylvania, on the invitation of Mr. T. D. Paret, of that place, and examined a number of interesting animal and other remains which were found there. The cave is partly filled with a bed of clay ten feet deep, on which rests a thin layer of stalagmite, and on this about a foot of black, friable earth mingled with animal and vegetable remains. The cave appears to have been too small to be inhabited by the larger carnivora, and no large entire bones of them were found, but about a half-bushel of fragments and splinters of limb-bones of smaller and large animals have been collected, many of which exhibit marks of having been gnawed, whether by rodents or small carnivora Professor Leidy does not assume to decide. Some of the splinters are derived from such large and strong bones that it is questionable whether even the largest carnivora could have produced them, and are presumed to be remnants of human feasts, in which the bones were crushed to obtain the marrow. A few of the bones are somewhat charred, among them a small fragment of a bison's jaw with a molar tooth. Most of the bones are of species still living, but some of them, as jaws of the reindeer, bison, and wood-rat, are of animals no longer belonging to the fauna of the State; and a few, as the teeth of the *Casteroides Ohioensis*,

and the jaws of a young peccary (*Dicotyles nasutus*), are of extinct animals. None of the remains have been identified as positively pertaining to our domestic animals, unless two of the teeth may be those of a fœtal or new-born horse. The vegetal remains include a few small fragments of charcoal and seeds of dogwood, pig-nut, and walnut. Remains of human work were found—a large stone celt of hard brown slate, from the bone-earth some distance within the cave; five bone awls, some of them gnawed; the prong of an antler worked so as to be barbed on one side; a needle of bone resembling a crochet-needle; a fish-hook of bone; and a cone-shell, of a species found on the western coast of Central America, bored through the axis as a head. Professor Leidy has, since exploring this cave, examined a collection of bones in the Museum of the Philadelphia Academy of Natural Sciences, which were found more than thirty years ago in the Durham Cave, Bucks County, Pennsylvania. The bones are of the same character as those of Hartman's Cave.

Temperature of the Breath.—We have before noticed the fact that the effect of breathing upon the bulb of a thermometer through several folds of flannel is to raise the temperature of the thermometer several degrees above that of the mouth and body, and the theory suggested by Dr. Dudgeon to account for the phenomenon, that the breath is the vehicle by which superfluous heat is removed from the body. Dr. William Roberts pronounces this theory untenable, and indicates, as an experiment that will show it to be fallacious, that a naked thermometer placed in the mouth, and breathed upon by expiration, will hardly rise to the normal temperature of that part of the body. He suggests another explanation, which has been accepted by Dr. Dudgeon. It is, that the temperature of the thermometer is raised by the action of the specific heat which is liberated by the condensation of the moisture of the breath. If the experiment of breathing is repeated with the same thermometer and flannel at short intervals, the degree to which the temperature rises decreases with each repetition till at last only a slight effect is produced. This is because the flannel, already charged with moisture, has a diminished capacity for condensing more moisture with every new trial of the experiment. If, on the other hand, the flannel is thoroughly dried before beginning the experiment, an increase of temperature to 115°, or several degrees higher than the highest noted by Dr. Dudgeon, is indicated immediately on breathing upon it. The capacity of the cloth for absorbing moisture has been largely increased by the drying.

Perforation of Lead Pipes by Rats.—We give herewith another well-authenticated case of the perforation of a lead water-pipe by rats, kindly furnished by Mr. Henry C. Hallowell, of Sandy Spring, Maryland. Mr. Hallowell writes: "As the confirmation of a statement is sometimes of value, I send a hasty sketch of a piece of lead pipe in my collection that has been gnawed by rats, as described by Dr. William Eassie, in "The Popular Science Monthly" for January. The pipe is one

Lead Pipe gnawed by Rats.

and one eighth inch in diameter, and the lead three sixteenths of an inch thick. The hole is three inches long, and appears to have been made to get to water."

The Manufacture of Indigo in Bengal.—Indigo is almost entirely obtained from leguminous plants of the genus *Indigofera*, of which two principal species are grown in India and America. The factories in Bengal are provided with filters, presses, a boiler, drying-grounds, reservoirs, and vats for fermentation. The plant is cut in the morning, and taken to the factory. In the evening it is loaded in the vats, tightly pressed down, and then submerged in water and exposed to a process of fermentation for from nine to fourteen hours. The progress of the fermentation is tested by draw-

ing off a little of the liquid, when, if it is of a pale straw-color, the quantity of indigo will not be so great, but the quality will be better than when it is of a deep-yellow tinge. The liquid, when it is drawn off after fermentation, is always of a more or less deep-yellow color. It is allowed to remain for some little time, and is then, while still warm, beaten with long bamboos for two or three hours. It gradually becomes of a pale-green color, and the indigo forms into small flakes. The mass is allowed to remain for half an hour, and the water is then turned off gradually by withdrawing one by one corks which have been placed at different levels in the vat. The water is returned to the river, and the deposit, which resembles a thin scum, is carried through a trough into a deep trench. It is then brought up and boiled for a short time to prevent a second fermentation, which would turn it black and spoil it. After about twenty hours, it is again boiled for three or four hours; then poured off, and strained through a filter. A thick, deep-blue paste, almost black, remains on the cloth of the filter after the liquid has been strained through. This paste is exposed to a pressure, which removes every particle of moisture, after which the indigo is found in a large, thick block, the cutting of which demands extreme care. The blocks are put in the drying-ground, a large brick building from which the light of the sun is carefully excluded, and, after from three to four days, are ready to be sent to the market.

Purification of River-Water by Organic Agents.—Mr. R. Warrington, in "The Chemical News," notices that, in the discussions on the qualities of river-water, the destruction of sewage which takes place in such water is in every case referred to the oxidizing influence of the air, and the action of organic agents is overlooked. Yet it is evident, and generally admitted, that these agents play an important part in the change of organic into inorganic matter. The process is in effect the joint work of a number of independent organisms having different functions, the action of one class following that of another, and each carrying the process through a particular stage. First are the fungi, whose main function is apparently the rapid oxidation of carbon; then come the bacteria, embracing many families of similar physical structure, but endowed with very different chemical powers. One class attacks nitrogenous organic matter and liberates nitrogen in the form of ammonia; another determines the conversion of carbonaceous organic matter into inorganic carbonic and nitric acids. Lastly come the chlorophyl-bearing plants to consume these products of the lower organisms; they also have the property of assimilating urea and inorganic ash constituents. These organisms must follow in their order, or they will fail to do their work. Sewage will finally be destroyed in a river of adequate temperature, unless the natural agents of oxidation are excluded by the addition to the water of chemical refuse fatal to organic life, or unless vegetation is prevented by artificial means. Temperature and light, or rather darkness, are important factors in the process. The experiments show that the oxidation in rivers increases as the temperature rises. The amount of dissolved matter in rivers is found to be greatest in February, when organic action is suspended, and least in September and August, when the action is most energetic.

Mind in Work.—It is set forth on the highest authority that whatever we do should be done with our *might*. This precept being interpreted means that there should be mind in work. The difference between a work of art and the product of machinery lies in the presence of a mark of mind directing the handiwork in the one case, while the other is simply a predetermined result produced by a duly formulated process wherein or whereby physical forces are directed and controlled by other physical forces on a set plan, to perform a defined series of actions, which *must*, in the nature of things, end in the production of the effect foreseen. Mind sets the one process, or series of processes, in operation, and they work out their physical destinies. In the other, mind is the active controlling power throughout. Starting from these premises, we are now concerned to point out that little or no success can be expected in any calling which does not suit the temper and bias of the mind

pursuing it. There can not be "might" or earnestness—of the best sort—in an uncongenial enterprise. It is not necessary that an occupation should be ardently loved, but it is indispensable that there should be some special fitness for a calling if the powers of mind are to be resolutely and effectually engaged. Medical men see a great deal of life, and nothing strikes the observant family practitioner more than the number of feeble, sauntering, and loitering minds with which he is brought into contact. No inconsiderable proportion of the common and some of the special ailments by which the multitude are affected may be traced to the want of vigor in their way of living. The human organism is a piece of physico-mental machinery which can only be successfully worked at a fairly high pressure. It will almost inevitably get out of gear if the propelling force is allowed to fall below a moderately high standard of pressure or tension, and that degree of tension can not be maintained without so much interest as will secure that the mind of the worker shall be in his work. It is curious to observe the way in which particular temperaments and types of mental constitution are, so to say, gifted with special affinities, or predilections for particular classes of work. The men who work in hard material are men of iron will, which is equivalent to saying that the men of what is called hard-headed earnestness find a natural vent for their energy in work that requires and consumes active power. On the other hand, the worker in soft materials is commonly either theoretical or dreamy. There is a special type of mental constitution connected with almost every distinct branch of industry, at least with those branches which have existed long enough to exercise a sufficient amount of influence on successive generations of workers. We are all familiar with what are called the racial types of character. It would be well if some attention could be bestowed on the industrial types, both in relation to educational policy and the study of mental and physical habits in health and disease.—*Lancet.*

Changes on the Moon.—A European astronomer, M. Jules Klein, affirmed, in March, 1878, that he had discovered evidence contradicting the generally received opinion that all action had ceased upon the moon. He claimed that he had observed a large depression, in the shape of a crater, newly formed to the east of the crater Hyginus, and that a large valley had been made south of the mountain called by Mädler the Colimaçon. His views were disputed, and it was said that he had seen, not something that was really new, but something that had been overlooked in previous observations. He defends the accuracy of his affirmation in a recent number of the "Astronomische Nachrichten" by producing evidence that the objects he describes had never been noticed, until he pointed them out, by astronomers who had made a constant study of the moon, and whom they could not have escaped if they had not been new. The original journals of Gruithuisen, which have just been published, bear directly upon the question. They are accompanied by the astronomer's original designs, which are of an astonishing fineness and accuracy. Among the designs is one including the crater Hyginus, with its great cleft, and Mount Colimaçon. The most minute details are given; but the depression in Hyginus is wholly absent, as is also the valley south of Colimaçon, although every other furrow on that side of the mountain, of which Gruithuisen made a special study, is scrupulously given. M. Klein describes his object as a large funnel-shaped crater, from which a shallow ladle-shaped valley extends toward the south, terminating in a small crater. The valley may be recognized, when it is not in shadow, as a gray spot. M. Klein believes, but does not undertake to prove, that nebulous clouds are produced on the moon which have no analogies on the earth; and that whoever examines the observations which have been made on the lunar formations from the time of Gruithuisen to the present will be convinced that changes for which we can not account are taking place on its surface.

The Ocean-Currents of Greenland and Iceland.—Captain N. Hoffmeyer, Director of the Royal Danish Meteorological Institute at Copenhagen, has published a summary of the facts ascertained in the recent deep-sea explorations of the Danish schooner

Fylla, Captain Jacobson, which help to explain why Iceland, lying nearly on the edge of the Arctic Circle, is not frozen like its neighbor Greenland. The first Norwegian Deep-Sea Expedition, under Professor Mohn, brought out the surprising fact that the bank on which the British Islands lie is connected by a submarine ridge, of at most three hundred fathoms below the surface of the water, with the Faroe Islands, and that these islands are similarly connected with the southeast coast of Iceland; further, it was discovered that over this bottom ridge separating the Atlantic water in its great deeps from the water of the Arctic Sea—at least in summer—a relatively warm mass of water was moving toward the northeast which fully prevented the cold bottom water of the Arctic Ocean from flowing into the North Atlantic basin. Since, however, the depths of the Atlantic are occupied with a bed of water only a few degrees above the freezing-point, the cooling of which can not be ascribed to circumstances of place and position, but must be caused by an inflow of polar waters, the fact ascertained by the Norwegian expedition that no such inflow takes place between Iceland and Europe, in the broadest passage between the two seas, has become of the greatest scientific importance. Attention was accordingly directed to the other passages between the two seas—the Denmark Straits between Greenland and Iceland, and Davis's Straits—concerning the features of which not enough was accurately known. The most that had been learned concerning them was the work of a few observers, chiefly Admiral Irminger, who, by comparing the annual reports of voyages between Greenland and Iceland, had found that the Atlantic water along the fifty-ninth parallel, between the Orkney Islands and 30° west, over an extent of about nine hundred nautical miles, had tolerably uniform and relatively high temperature on the surface with a superficial current to the north; that, further, in consequence of this current, the warm surface-water, at least in summer, reached the south coast of Iceland essentially unchanged in temperature, and was directed thence toward the northwest and north into the Denmark Straits and along the west coast of Iceland; that, on the other hand, a cold stream filled with thick drift-ice flowed from the Polar Sea along the east coast of Greenland through the Denmark Straits to Cape Farewell, and was strong enough to reach over to the northwest coast of Iceland and fill its fiords with ice. As an offset to this, the ice does not, even in winter, enter the great bays of the west coast of Iceland, and the fisheries are prosecuted in those waters through the whole year. North of Iceland the stream sets decidedly toward the east, and often brings with it Greenland ice, which blockades the whole coast for a longer or shorter time. Admiral Irminger believes that this stream is a branch of the great East Greenland ice-stream which has rebounded from the northwest coast of Iceland and been deflected to the east. Other investigators have reached conclusions agreeing with these. In order to determine the matters which were in question, the Danish Government, in 1877, provided the Fylla with the necessary apparatus and ordered Captain Jacobson to take soundings and measurements of temperature. He performed his work with much energy, against many difficulties, and discovered that the warm stream which had been mentioned as washing the west coast of Iceland has considerable depth, and that it is strong enough at the North Cape to pass around it in its continued progress along the north coast of the island. The meteorological observations in the Island of Grimsey have also shown that this warm stream affects the island in the same way in the winter and considerably moderates its climate. Nevertheless, in severe winters, the Greenland ice pushes far down and causes the warm current to be covered with its cold meltings; the season is protracted, and Iceland suffers a bad year with hardly any summer.

Stammering.—Stammering, according to M. A. Chervin, generally originates in a sudden nervous shock which the victim of the affection has received in childhood; sometimes it is a habit which has been acquired by the practice of imitating other persons who stammer, or by constant association with stammering members of the family. It takes place whenever the rhythm of respiration is interrupted by the effort to speak being made at the wrong stage of breathing. Speaking, to be easy and regular,

should be an act of expiration. Some persons begin to speak while they are drawing their breath, but are compelled to halt as soon as they have uttered the first syllables. They spit out their syllables; then, suffering an oppression of the chest, are compelled to relieve themselves from it, and the rest of the phrase goes out in a gasp. Others speak during the period of expiration, but do not begin until the lungs have been nearly emptied and have not air enough to keep up the action of their vocal organs. Others speak through their nose and fail in the utterance of the stronger consonants. Stammerers are not always equally liable to suffer from their affliction, but the intermittence is not regulated by any law. Sometimes they may be helped over the difficulty by pronouncing the embarrassing word for them; sometimes by a little diversion of attention. Children who stammer much are often able to speak with perfect freedom under circumstances in which they are free from embarrassment, as the stuttering boy playing with his dog, or the girl with her doll; but, if another interrupt them with the most simple question, they will begin to halt in their speech. The fault may often be alleviated or made to disappear by reading or speaking aloud when alone. Some persons are accustomed to use, before the syllables which give them difficulty, certain words which seem to them to smooth the way of the rebellious consonant. One stammerer is mentioned by M. Chervin who had the habit of saying *et, mais, oui* (and, but, yes), before every difficult word, whatever it might be, which often gave a ludicrous turn of expression to his remark. The same expedients do not, however, always have the same operation with different persons, and sometimes result oppositely with the same person. Singing is nearly uniform in its action. In chanted or rhythmic speech, as in the recitative of operas, stammering is very rare. Singing, reduced to its most simple element, cadence, enters largely into the application of the means employed by M. Chervin for the cure of the affliction. The poetic cadence in the declamation of verse and the variety of intonations which give to poetic diction a character very different from that of familiar conversation, are generally effective in preventing halting in the speech. More than this, it is often enough to speak or read in the same measure with a stammerer to make it more easy for him to speak or read. The accompaniment serves as a kind of support or guide, which affords incontestable assistance in a majority of cases. Generally, reading and recitation are easier than conversation, especially if they are carried on in a low voice. It is proper to remark, in connection with this point, that with all stammerers whose difficulty is accompanied with glottic spasms, articulation in a low tone, diminishing the play of the vocal chords, operates as a restraint upon one of the provocations to stuttering. There is no resemblance between stammering and what is called writer's cramp, which results from the excessive use of an organ; no connection between it and paralysis. When it occurs with paralysis, it is only as one of the symptoms. In the majority of cases it appears as a single infirmity in subjects otherwise healthy, is generally wholly curable, and may be ameliorated in the most rebellious cases.

Turquoises.—All the turquoises in Europe come from one mine, which is situated in Persia, on the road from Teheran to Herat, not far from Meschid, the capital of Khorassan. Two kinds of turquois are distinguished in mineralogy: the real stone turquois, or calaite (in Persian, *sengui*), and the osseous turquois or odontolite. The latter is considered a false turquois, and is supposed to be composed of a piece of bone colored with phosphate of iron. The Persians again divide the real turquoises into two kinds—the *sengui*, or stony, and the *khaki*, or earthy, turquois—accordingly as they are incrusted with the rock, or are obtained by washing the earth, and are clear of foreign matters. The mines are at the village of Maden, in the region of the salt-mines of Doulet Aly. The salt district is like an immense block of salt just covered with a thin soil of red clay. The miners get out the salt by making a hole, putting a ball of clay into it, and striking upon the clay till a block is detached. The hills in which the turquoises are found have the same reddish-gray aspect as is remarked in the salt-rocks; they are formed of rocks and an earth full of pebbles, and are bored in their whole extent with galleries, tunnels, abandoned pits,

and land-slides, which give the place a curious aspect. The mines belong to the Government, as do also the salt-mines, and are farmed out for a small sum. They are not very actively worked, and the product is small. The process for extracting the gems is much like that pursued in mining for the salt, except that, instead of using a ball of clay, the miners burn a bunch of dry grass in the hole, taking precaution, as soon as the cracks appear, not to damage the turquoises which may be incased in the block. The stones are generally found in groups, often numbering twenty-five or thirty, incrusted with a thin calcareous envelope which is white next to the mineral, brown on the side next to the rock. The *khaki*, or earthy turquoises, are found in the valley adjoining the hills, in a soil composed of gravel and rounded stones resting on a clay subsoil. After the earth has passed through two or three washings, a considerable number of turquoises are left, of moderate size, but pale and of little value, if the diggings are fresh. The turquoises in the older pits have a better color, because, the miners say, the stones acquire their color with age. Among the largest turquoises which have been mentioned are one of which a drinking-cup was made for the Shah of Persia, and one in which the treasure of Venice was kept, and which weighed several pounds. Generally the large turquoises are pale or discolored, and of little value, and are used principally for the decoration of furniture, and of the saddles and bridles of rich Persians.

Heat in Tunnel-Excavations.—Dr. F. M. Stapff, engineering geologist of the St. Gothard Tunnel, has published, in the "Revue Universelle des Mines," the results of the studies he made during the progress of the operations in the tunnel as to the highest temperature at which men can work underground, and the depth below the surface at which that temperature is likely to be met in tunneling. The limit of temperature at which men can work depends upon the length of their exposure, the amount of exertion they put forth, their condition, and the nature of the atmosphere, particularly as to its degree of moisture. It is certain that men can not become used to stand, for any length of time, a higher degree of temperature than from 140° to 165° Fahr., even when they keep perfectly still, and are in quite pure air. Men have worked at 104° on railways in the United States and Mexico, at 72° to 94° in Belgian collieries, at 125°, under exceptionally favorable conditions, in the Fahlun copper-mine in Sweden, and are said to work occasionally in the stoke-holes of tropical steamers at 156°. The highest temperature observed in the Mont Cenis Tunnel was 86°. In the St. Gothard Tunnel work was carried on at 87° on the Airolo side, in an atmosphere saturated with moisture, and at 84° on the Göschenen side, in an atmosphere less highly impregnated. Professor Du Bois-Reymond estimates that men can stand a temperature of 122° when the air is as dry as possible, but that even 104° is likely to be fatal in an atmosphere saturated with moisture; and he recommends quick lime, notwithstanding the heat it gives off, as preferable for counteracting the heat, because it absorbs the moisture, to ice, which adds to it. Salt and ice are, however, good. The highest limit of air-temperature theoretically possible in tunnel-work would be that which would induce fever-heat, or 107° in the body; the highest practicable, but still a dangerous, temperature should not raise the heat of the body over 104°. On this basis an extreme temperature of 114° would be admissible at the Göschenen end, and of 100° at the Airolo end, of the St. Gothard Tunnel. The temperature within the borings of the St. Gothard Tunnel was found to increase with the depth of the excavation, at a general average rate of 1° Fahr. per 88·1 feet of vertical depth below the surface of the mountain. The rate is subject to local variations, giving sometimes as much as 9° of error, arising from irregularities in the surface of the mountain. Thus the actual temperature is higher than the calculated temperature under depressions of the surface, and lower under peaks; but for considerable lengths of tunnel the calculated and actual temperatures substantially agree. Dr. Stapff estimated, when the excavations at St. Gothard had been driven to within about one thousand yards of the middle of the tunnel, that the temperature at the middle, before piercing the wall between the two excavations, would be 89° for the rock, and the same for

the air about one hundred and fifty yards behind either fore-breast. The actual temperatures in March, 1880, after the two excavations had been connected, were 87°. The temperature of the air immediately at the two fore-breasts was brought down to 82° Fahr., while boring, and to 86° Fahr. while clearing away the *débris*, or to about 5° below the calculated point, by the operation of an extra supply of compressed air. The question of cooling the air in the tunnel-galleries presents great difficulties, for the heat of the rocks is inexhaustible, and the air, no matter in what condition it may be delivered, becomes heated up again nearly as soon as it is distributed. The use of jets of water is objectionable on account of the increase of dampness that attends it, and the mists to which it gives rise. Dr. Stapff is not able to recommend any better cooling apparatus than a combination of the cooling mixture of ice and salt and quicklime.

Relation of Elevation and Exposure to Rainfall.—M. Th. Moureaux has drawn up a set of maps based upon the reports of the Central Meteorological Bureau of France, which show what was the distribution of rain over the country for each month of the year, and for the whole year, 1878. Except in February and September, which were dry, the year was a moist one; the rains were excessive, except in the Mediterranean littoral and some parts of the valley of the Saône. The amount of rain increased with the height of the locality. The map shows at the first glance that the low regions, the plains, correspond with the smallest falls. The minima were constant during the whole year; in constructing the monthly maps, the absolute minimum in each month was found to be on the littoral of the Mediterranean, and the relative minima were found to correspond to the large valleys, whatever might be their direction. The valley of the Loire below Orleans, and those of its affluents on the left bank, the basin of Paris, the valleys of the Garonne, of the Saône, of the Lower Rhône, were regions in which relatively little water fell. In mountainous regions, at the same height, the rains were much more abundant on the slope exposed to the direct action of moist winds than on the opposite slope. When a mass of air rose along the side of a mountain, it became steadily cooled, its load of moisture was relatively increased, and the clouds soon precipitated their burden; the condensation was more active as the difference of temperature increased, and as the air of the plain approached the point of saturation. The inverse phenomenon was produced on the opposite slope. Descending the side opposed to the direction of the wind, the air became warmer, and its temperature further and further from its dew-point; the rain was light and often there was none. The minima were thus constant during the several seasons. The same was not the case with the maxima. They could be divided into three groups: 1. Those maxima wholly due to altitude; 2. Those which were attributed to the combined influence of altitude and of the situation as related to moist winds; 3. Those which were connected with the action of neighborhood to the sea. In the first group, the rule was absolute; the highest points constantly received more rain than the surrounding places of a less altitude. But this was not the case with the maxima which were due to the neighborhood of the sea or to exposure to rain-bearing winds. The maxima of the hills of Normandy, Brittany, and Poitou were due to the fact that those provinces lay near and to the east of a great mass of water. This influence was made effective by the frequency of winds from the west, which drove toward those regions the moist air of the ocean; accordingly, it was most clearly manifested during the cold season; but the maxima were considerably lessened, or disappeared when the rains came from the southeast. So the maximum of the gulf of Gascony resulted from the predominance of winds from the west or northwest; and, when the south winds were pouring torrential rains into the basin of the Rhône, but little water fell in the basin of the Adour. Heavy rains did not fall simultaneously over the whole of the central plateau. They were limited to the slopes exposed to the direct action of rain-bearing winds. When brought by winds from the south or southwest, as was most frequently the case, they fell upon the side toward the ocean; while, when they came from the south and southeast, they were deposited on the

Mediterranean slope. The laws of the distribution of rains, which M. Belgrand announced in 1865 for the valley of the Seine, are verified by the maps, and their general application appears to be made more clear every year.

The Asteroids and Jupiter.—Dr. J. Holetschek has published, in the "Deutsche Rundschau," a summary of our present knowledge of the asteroids, or the group of bodies which revolve in orbits between those of Mars and Jupiter. Of the two hundred planets of this group which had been discovered in July, 1879, sixty-three were discovered in the United States, sixty in France, twenty-eight in Germany, seventeen in Austria, fifteen in Great Britain, eleven in Italy, five in Asia, and one in Denmark. Professor Peters, of the Clinton Observatory, has discovered more (thirty-six) than any other single observer. The orbits of one hundred and seventeen were calculated in Germany, those of forty-eight in the United States, and those of the others in Austria, France, England, Russia, and Sweden. The theory at first adopted that these bodies are the fragments resulting from the explosion of a larger planet, was contradicted by the calculations of Professor Newcomb, in 1860. D'Arrest sought to establish the fact of a connection among them by finding relations in the eccentricities of their orbits, but the elements of the planets discovered since have set this theory at rest. The idea of a collision of two bodies has also been given up. The little planets mock all attempts to combine their relations, and each asserts its individuality as an independent member of the solar system. They exhibit common features only in the limitation of their orbits, so far as the discovery of them has extended, to a particular zone, and in a corresponding limitation of their periods of revolution around the sun. Taking the earth's mean distance from the sun as unity, the halves of the major axes of their orbits may all be represented by numbers between two and four. Their periods of revolution around the sun are between four and eight times that of the earth. Great variations occur within these limits. Very perceptible and peculiar intervals exist in several cases in the mean distances of particular asteroids from the sun, which might once have been accounted for by supposing that there were planets not yet discovered which would occupy them. But as the numerous discoveries of new planets have failed to furnish the bodies sought for, and have rather rendered the gaps more obvious, it has been suggested that the vacancies are not casual, but are owing to a real natural cause. A theory has been suggested that they are occasioned by the attraction of Jupiter, and is supported by the fact that a vacancy exists at every distance from the sun at which the time of a planetary revolution would bear a definite relation to the year of Jupiter. A planet could not continue in such a position, for it would be subjected to disturbances at every conjunction with Jupiter, the effect of which would be to draw it out of its course and out of its relation with the larger planet till it found a new period of revolution not commensurable with that of Jupiter. A large gap exists between the asteroids Gerda and Sibylla, in the place which a planet making two revolutions to one of Jupiter would occupy. Gerda, having an orbit interior to this place, completes its revolutions in fifty-four days less; Sibylla, with an exterior orbit, requires a period one hundred and two days longer than that of half the year of Jupiter. Similar gaps exist at distances where planets, if there were any there, would have periods of revolution corresponding to two thirds, two fifths, three fifths, two sevenths, and three sevenths of that of Jupiter, although planets are found on either side of these spaces whose periods of revolution bear no fractional relation, or an extremely remote one, to that of Jupiter. Saturn also produces modifications in the position of the asteroids which are less noticeable on account of its greater distance and lighter mass.

The Diffusion and Softening of the Electric Light.—M. L. Clémandot, a French engineer, has invented a new arrangement for the diffusion of the electric light, which, he claims, presents considerable advantages over the opaque globes hitherto employed for that purpose. The globes operate by absorbing the light until they become luminous—a process in which a considerable pro-

portion of the light is wasted. M. Clémandot aims by his process to make all the light available for illumination. It is based on the principle which governs the diffusion of the light of the sun. This is effected by vapors floating between us and the sun, which distribute the light equally without stopping more than a very small proportion of it. To imitate these vapors he uses a solid substance, but in a condition so attenuated as to be, for practical purposes, almost the same as vaporous. It is glass, spun into threads one hundred and seventy-five times finer than a hair, or forty-five times finer than the finest silk fiber, with which he surrounds the light with a double envelope. His glass-fleeces are put into a lantern constructed especially for the purpose, so as to exclude dust, the glasses of which may be given any desired degree of opacity, and any color, including those colors which will neutralize the injurious properties of the electric light. The apparatus can be adapted to any of the systems of electrical lighting.

William Lassell.—William Lassell, LL. D., F. R. S., the famous astronomer and maker of telescopes, died October 5th, in the eighty-second year of his age. His name is closely associated with the history of the reflecting telescope. About 1820, not having sufficient means to enable him to buy expensive instruments, he began to construct reflecting telescopes for himself, beginning with a Newtonian and a Gregorian telescope of seven-inch aperture, with which he succeeded so well that he was encouraged to make a Newtonian instrument of nine-inch aperture. In 1844 he began an instrument of two feet aperture and twenty feet focal length, in the making of which he introduced many improvements over the similar instrument of the Earl of Rosse. With this instrument he discovered the satellite of Neptune in 1846, the eighth satellite of Saturn, simultaneously with Professor Bond, in the United States, in 1848, and two satellites in addition to the two already known, of Uranus, in 1851. He afterward made an instrument of four-feet aperture and thirty-seven feet focus, which he set up at Malta, and with which he made numerous observations of nebulæ and planets, besides preparing a catalogue of six hundred new nebulæ discovered at Malta. His latest recorded work was the construction of an improved form of machine for polishing large telescopic mirrors, which is described in the "Transactions of the Royal Society" for 1874.

Climatology of Europe. — The climate of Western Europe is ameliorated by the warmth of the Gulf Stream in winter, and by the neighborhood of the ocean in summer, and approaches what is called an insular climate. In Eastern Europe these modifying influences cease to be felt, and the climate gradually assumes a continental character, with greater differences of temperature, colder winters and warmer summers. The differences in the summer temperatures of the eastern and western regions are less marked than those in the winter temperatures, and amount at most to about 27°. For the greater part of the continent the difference in the temperature of July is not more than about 18°. The mildest summers are felt in Ireland and Norway, and the hottest in Southeastern Europe. The difference is perceptible between places in corresponding latitudes in the southeast and southwest. Thus, Syracuse is 7° and Sebastopol is 5½° warmer in July than Lisbon and Oporto. A similar difference, but less in extent, appears in going eastward along the northern parallels. The differences in the winter temperatures of the several parts of the continent are much more marked than are those of the summer temperatures. The mildest winters are felt along the Mediterranean coast and in the Iberian Peninsula, where the mean temperature in January is from 16° to 19°. The next mildest are those of the western coast of France and the southern coast of England and Ireland. The winters of western Scotland and the Orkney and Faroe Islands are milder than those of Berlin and Milan; those of the Arctic coasts of Scandinavia than those of the Gulf of Bothnia, as is shown by the fact that the Arctic fiords of Norway, even as far as North Cape, are not frozen, while the Gulf of Bothnia is regularly frozen in winter. In Russia the January temperature diminishes as we go east, so that, while it is about 24° at Warsaw, it is reduced to 4° at Uralsk. The highest annual mean temperature, the

mildest winters and the warmest summers, must be looked for where the land approaches the thirty-fifth parallel, at the southern points of Spain, Sicily, and Crete. The highest known mean in Europe is at Catania, 65°, the temperature of January being there 51°, and that of August 81°. Gibraltar enjoys a warmer temperature in January, 54°, nearly corresponding with the temperature of Cairo. The January of Catania is like that of the end of April, the January of Gibraltar like that of the first half of May, in Berlin. These extreme southern points suffer, however, occasionally from frost and snow. Snow fell on the African coast in 1845 and 1850, and in the latter year a temperature below the freezing-point was observed as far south as the Sahara; and the Nile is said to have been frozen in the year 859. So it is safe to assume that no place in Europe is secure from snow and frost.

A New Theory of Chemical Affinity.—M. Berthelot has endeavored, in his recently published "Essai de Mécanique Chimique fondée sur la Thermochimie," to connect the laws of chemistry and the theory of the unity of physical forces. He believes that he has discovered a direct relation between chemical affinity and the capacity of different bodies in combining to throw off heat. Thus hydrogen burns in oxygen, liberating enormous quantities of heat; the affinity of the two bodies is known to be strong. The same is the case with phosphorus and oxygen. But nitrogen and hydrogen, instead of liberating heat when they combine, absorb it. Their affinity for each other is feeble. Again, when two bodies combine in different proportions, forming different compounds, it is always the combination in which the most heat is liberated that tends to form. More heat is liberated in the formation of water than of the binoxide of hydrogen, and it is water that is naturally formed when the bodies burn together. This law of chemical compositions and decompositions has been termed by M. Berthelot the *principle of maximum work*, and is enunciated by him thus: Every chemical change accomplished without intervention of a foreign energy (heat, electricity, light) tends to the production of the body or system of bodies which liberates heat. This principle throws light on a multitude of facts hitherto unexplained. M. Berthelot indicates many applications of his principle. Acetic acid, combining with soda, produces a certain amount of heat, and forms acetate of soda; hydrochloric acid, combining with soda, liberates more heat, and forms chloride of sodium. If, now, we apply hydrochloric acid to the acetate of soda, chloride of sodium will be formed, with the production of an amount of heat just equal to the difference between the heat of formation of acetate of soda and that of chloride of sodium; but the converse will not take place when acetic acid is mixed with chloride of sodium. Combinations which are formed with much liberation of heat are very stable; those in which heat is not liberated are unstable. Chloride of sodium will resist a white heat without decomposing, while chloride of nitrogen, in the formation of which heat is absorbed, will decompose and explode spontaneously. This fact leads to another remark: that, in accordance with the law of maximum work, all explosive bodies are bodies that produce heat in being decomposed.

Diseases of Miners.—Dr. Paul Fabre, of Commentry, France, has made a particular study of the diseases of miners. He has found that diseases, the character of which is largely governed by certain accessory circumstances, are prevalent among workmen who labor in damp or wet galleries. No morbid symptom is developed among those who work in a gallery which is simply damp and of a temperature of not more than 58°. But if cold water falls upon them, or if they have to put their legs in water, they become subject to lumbago, sciatica, to indefinite pains in their limbs, and often to a real rheumatism. The rheumatism is generally subacute, sometimes chronic, and most often localized in a single joint—generally that of the left knee, on which the pick-men and heavers rest in working. In galleries which are saturated with moisture and where the temperature exceeds 77° to 86°, the workmen are soon overcome with an extreme lassitude; they get hot, they gasp for breath, the sweat rolls down their bodies, and they are obliged to stop working and rest for a while in a cooler spot. A rapid

enervation which compels frequent changes of the men in the gallery, sudoral or miliary eruptions, sometimes boils, rarely eczema, are among the phenomena which Dr. Fabre has most frequently observed in these conditions. If, while the gallery is constantly damp, the air is vitiated by poisonous or irrespirable gases, and if the water contains sulphates or sulphuric acid in solution, the men, in addition to pains in their limbs and difficulties in breathing, experience lively itchings and painful smarts wherever the surface of the skin has been abraded. Those who have labored for a long time in the damp galleries contract a chronic inflammation of the gums, together with muscular pains in the limbs, and have often intestinal troubles and spots of purpura. These phenomena indicate the coming on of a mild form of scurvy. The remedies are to be found in whatever will improve the sanitary conditions of the mines and the homes of the miners, and in the usual applications for scurvy whenever the symptoms of that disease appear.

Variability of the Level of the Ocean.—M. H. Trautschald, of Moscow, lately sent in a paper to the Geological Society of France, maintaining that the level of the ocean was not invariable, in which he expressed the following conclusions: 1. The level of the sea has fallen, as parts of the earth's crust have risen from the bottom above its surface; 2. The surface of nearly all the continents has once been at the bottom of the sea, and has risen from the waters, partly in consequence of upheavals, partly in consequence of the retreat of the ocean; 3. When the continents have been formed, a part of the waters of the seas is carried away from them, and held on the land as lakes, rivers, eternal snows, and as a constituent of organic matter—thus the quantity of water in the ocean has been constantly diminished, and its level has fallen; 4. As the earth cools, ice accumulates near the poles and on the mountains, water is soaked down more deeply into the crust of the earth, and mineral hydrates are formed everywhere. It follows that the level of the sea has been gradually falling ever since water has existed as a liquid upon the earth.

Spiders and Tuning-Forks.—According to observations recorded by Mr. C. V. Boys, in "Nature," spiders are very sensibly affected by the vibrations of a tuning-fork, and act toward it as they would toward a fly that comes to their web. When a fork, lightly touching a leaf, or other support to the web, was sounded, the spider, if at the center of the web, would face the fork and feel with its fore-feet to find along which radial thread the vibration was traveling. Having become satisfied on this point, it would run along the proper thread till it reached the fork, or, if it came to the junction of two threads, would first stop and determine which was the right one. If the spider was not at the center of the web, and was not on a thread in contact with the fork, it had, when it perceived a vibration, to go to the center to see which radial thread was vibrating. It would then run out to the fork. If the fork was not removed when the spider had reached it, it would seize it, embrace it, and run along on the legs of the fork as often as it was made to sound, "never seeming to learn by experience that other things may buzz besides its natural food." If, when a spider had been enticed to the edge of the web, the fork was withdrawn, and then gradually brought near, the spider seemed aware of its presence and direction, and would reach out after it; but, if a sounding-fork was gradually brought near a spider that had not been disturbed, the spider would instantly drop; then, as soon as the fork was made to touch any part of the web, it would climb back and reach the fork with marvelous rapidity. By means of a tuning-fork a spider could be made to eat what it would otherwise avoid—even a fly dipped in paraffine—if its attention was kept fixed by the constant vibration of the fork.

Deterioration of Binding in Libraries.—Mr. H. A. Homes, in the "Library Journal," notices some causes additional to those arising from the use of gaslights, which may conduce to the deterioration of bindings in libraries. The modern methods of tanning do not give as durable a leather as the old processes, which it took months or years to complete. This may be the

reason that the goat-skins of Turkey, in the tanning of which there is nothing modern or "improved," are still recognized as furnishing the best leather for bindings. The sulphide of sodium that is sometimes used in tanning may supply a part of the sulphur that is complained of in modern libraries. A second cause is the practice of using split skins, which gives a binding only half as strong and lasting as the old whole skins; and a third cause may be found in the gases escaping from the hot-air furnaces with which libraries are warmed, which are hardly less destructive than the products of illumination, and are more constantly in action.

Mixed Education.—Professor Alexander Hogg, in a note reprinted from the "Proceedings of the National Educational Association," refers to the perplexities arising from mixing military with industrial education in the Agricultural and Mechanical College of Texas. A cadet failed to receive promotion at the hands of the faculty, and the board of directors confirmed their decision, and then turned out the whole faculty. Professor Hogg says that serious troubles have befallen these institutions in several States, and remarks: "With regard to the cause, I venture to suggest that it will be found that it has all grown out of the complications of attempting to run in the same institution these three leading features, viz., agricultural, mechanical, and military education. The military, so far as I have been able to learn (and this is corroborated by my personal experience), is the source of all the troubles. And this, I think, grows out of the further fact that the military, to be of any use whatever, must be thoroughly equipped in all its departments and requirements, while the act of Congress, granting lands for the support of these colleges, intended it should be secondary, and cultivated entirely as a means of discipline and good order—not at all intended to make proficients in arms, but simply as a gymnastic exercise."

Rate of Growth of Coral.—Light is thrown on the question of the rapidity with which corals grow, by the case of specimens of living coral which were recently found on the hull of the French man-of-war Dayot, after a cruise of a few months in the South Pacific Ocean. When the vessel reached Tahiti, several corals were discovered growing on the copper sheathing, the longest of which was a *fungia* of discoidal shape nine inches in diameter, and weighing when half dry two pounds and four ounces. The Dayot had entered tropical waters several months before, but had not made a long stay in any harbor until she reached the Gambier Islands, where she remained for two months in the still waters of a coral basin. Thence she sailed direct for Tahiti. A young *fungia* probably became attached to the sheathing of the ship in passing the reef, where the vessel rubbed, and grew to the size and weight it had attained when observed, in nine weeks.

NOTES.

FLEUSS's diving apparatus, which we described several months ago, has been used with success at the Severn Tunnel by a professional diver, who with it reached the bottom of the shaft under thirty-five feet of water, and walked more than a thousand feet up a heading to close some sluices and shut an iron door. He was cut off from all communication for an hour and a half. The ordinary diving gear had been tried for this work without success, for the great length of tubing required in connection with it rendered its use impracticable.

THE suffocation of infants by overlying in the night has recently been investigated by a London coroner, who found that the abuse of alcohol was the principal cause of this form of mortality. Most of the cases occur on Saturday nights following the weekly debauch of the poorer classes among which they happen. The mother goes to bed in a state of semi-intoxication, nurses the baby with alcohol-poisoned milk, and both sink into a sort of drunken stupor, of which the infant becomes the victim.

THE death is announced of Francis Trevelyan Buckland, best known as Frank Buckland, a popular writer on subjects of natural history, and a constant contributor to "Land and Water." He was a son of Dean Buckland, author of the work on geology in the "Bridgewater Treatises," which he edited in 1858, was himself a writer "who could seize with alacrity the popular side of a scientific question, but seldom went deeper," and was an authority on subjects relating to fish and fish-culture.

THOMAS RYMER JONES, Professor of Comparative Anatomy at King's College, London, has recently died. He was author of a "General Outline of the Animal Kingdom," which was forty years ago considered the best book of its kind in England.

THE apparatus invented by Mouchat for utilizing the direct rays of the sun as a source of power has been so improved by M. Pifre, a French engineer, that he claims to be able to make available eighty per cent. of the received heat of the sun.

THE organization of an entomological club has recently been completed in this city by the election of Professor A. R. Grote as President, M. Berthold Neumoegen as Treasurer, and Mr. Harry Edwards as Secretary. Its object is the promotion of entomological science, and the formation of a metropolitan collection of entomological objects. The constitution provides for the publication of a journal devoted to the different branches of entomology, the first number of which is issued for January of this year.

PROFESSOR HUXLEY, in a recent paper before the London Zoölogical Society, said he was not aware of any zoölogist who now maintains the independent creation hypothesis.

SIGNOR SERRANO FATIGATI has made researches into the influence of different colors on the development and respiration of the infusoriæ, which lead to the following conclusions: 1. Violet light promotes, green light retards, the development of these lower existences; 2. If a number of these organisms are put in distilled water, they will die quicker in a violet light than in a light of any other color; 3. The production of carbonic acid is greater in violet, less in green light, than in any other color; 4. All of these circumstances indicate that the respiration of the infusoriæ is faster in violet, and slower in green light, than in any other color.

DR. HENRY DRAPER having reported to the French Academy of Sciences that he had succeeded in taking distinct photographs of the nebula in Orion, which would be useful in the future to show if any change should take place in that object, M. Janssen has proposed that systematic stellar photography be undertaken at as great a number of observatories as possible. He is preparing to begin such a work at the observatory at Meudon, with which he is connected.

THE experimental electric railway proposed about a year ago by Siemens has been built between the Anhalter Station, in Berlin, and a suburb called Lichtenfeld. It was to be opened to the public about the first of February.

THE Boston Free Library contains three hundred and sixty thousand books, and last year there were taken out eleven hundred and sixty thousand volumes.

THE phylloxera has appeared in the Crimea, imported, it is supposed, with vines from France. It has extended very slowly hitherto; but fears are expressed that it may invade the wild vineyards of the country, when it might destroy all the vines in the valleys of the Rion and Kura Rivers.

THE sinking of the base of the French entrance to the Mont Cenis Tunnel has obliged the railway company to bore a new entrance, which has been begun a little over half a mile to one side of the present opening, and will join the old tunnel at a point about two thousand feet from its mouth.

IN Siberia, a country so rich in gigantic fossils, the body of a colossal rhinoceros has been discovered in the Werchojanski district. It was found on the bank of a small tributary to the Jana River, and was laid bare by the action of the water. Similar to the mammoth washed ashore by the Lena River in 1799, it is remarkably well preserved, the skin being unbroken and covered with long hair. Unfortunately, only the skull of this rare fossil has reached St. Petersburg, and a foot is said to be at Irkutsk, while the remainder was allowed to be washed away by the river soon after it had been discovered. The investigation of the skull gave the interesting result that this rhinoceros (*R. Merckii*) is a connecting form between the species now existing and the so-called *Rhinoceros tichorrhinus*, remains of which are not unfrequently found in the gravel strata of eastern Prussia. It is supposed that *R. Merckii* is the now extinct inhabitant of the eastern part of Siberia.—*Nature.*

DR. B. A. GOULD, Director of the Observatory at Cordoba, in the Argentine Republic, has been elected correspondent of the French Academy of Science, in the place of the late Professor C. A. F. Peters.

DIED in Liverpool, January 3, 1881, Mr. John T. Towson, aged seventy-seven years. Mr. Towson was well known for valuable investigations relative to the subject of navigation, especially the determination of quickest routes to trans-oceanic ports, and the deviation of the compasses on board of iron ships. In 1863 he prepared a manual entitled "Practical Information on the Deviation of the Compass, for the Use of Masters and Mates of Iron Ships," which was subsequently published by the English Board of Trade.

PROFESSOR HUXLEY has been appointed to the inspectorship of fisheries, a position made vacant by the death of Mr. Frank Buckland.

MICHEL CHASLES.